

# **Performance and Safety of COTS 18650 Li-ion Cells from Various Manufacturers**

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# Outline

- Cell Characteristics
- Performance of Panasonic Cells
- Safety of Panasonic Cells
- Performance of Moli STOBA cells
- Safety of Moli STOBA cells
- Performance of LG cells at Different Temperatures

## 18650 Lithium-ion cells

Panasonic 3.1 Ah



LG 2.8 Ah



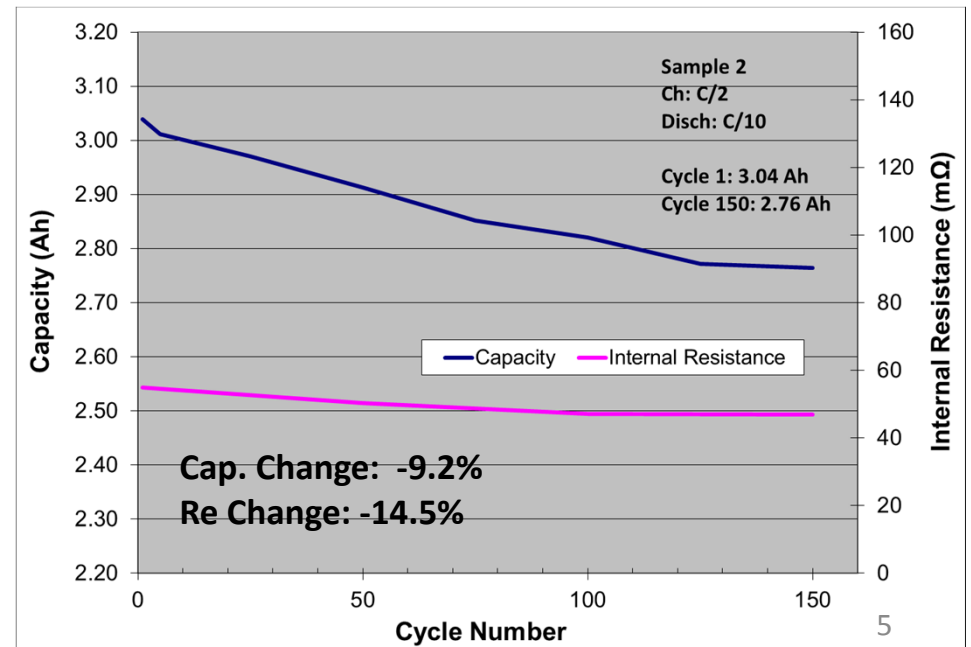
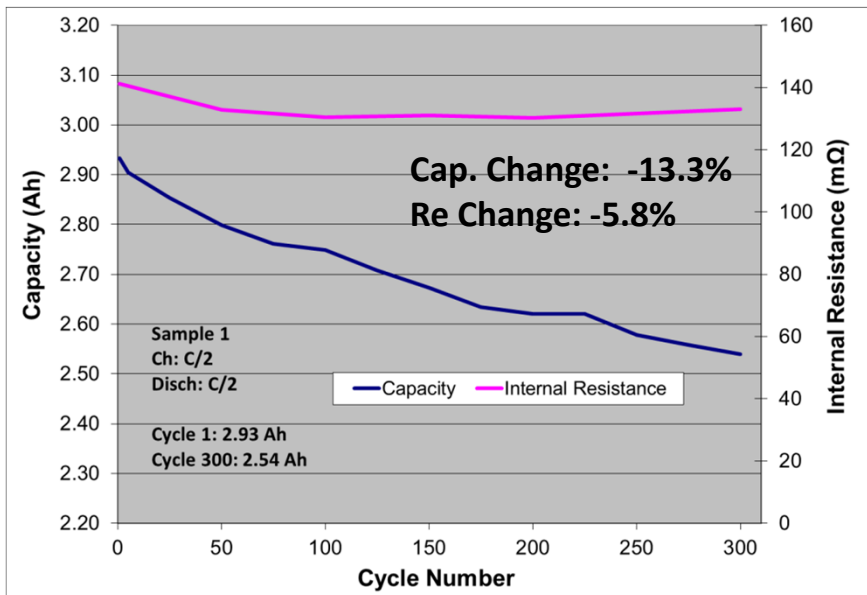
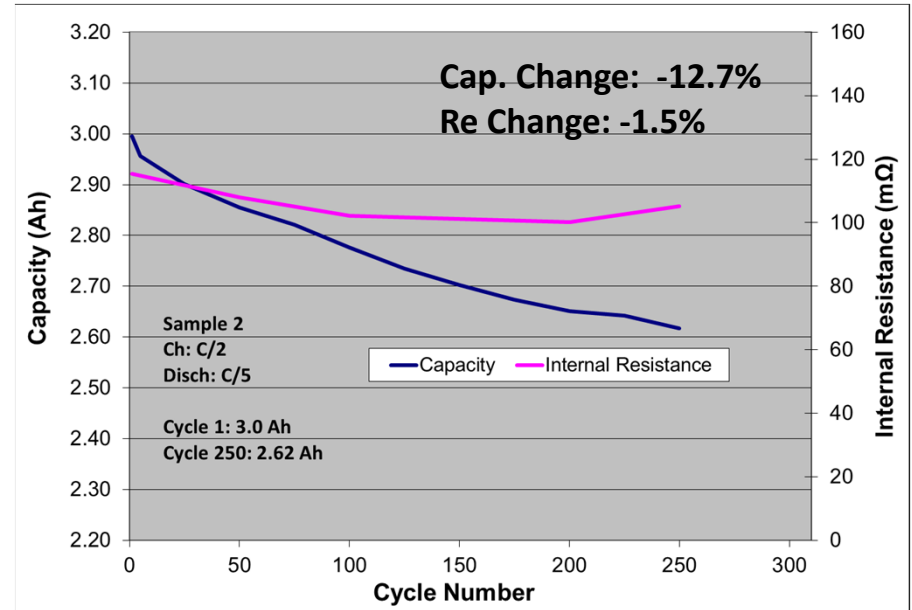
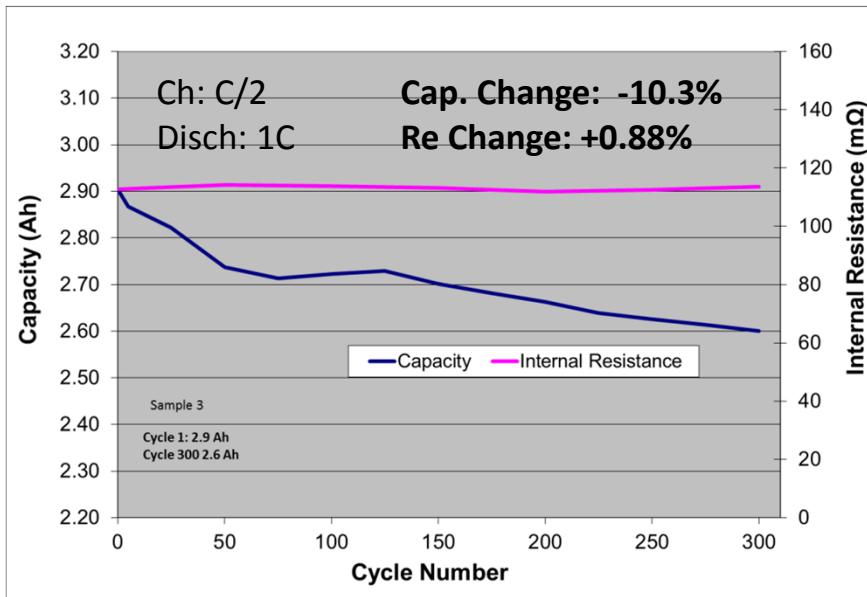
Moli STOBA 2.0 Ah



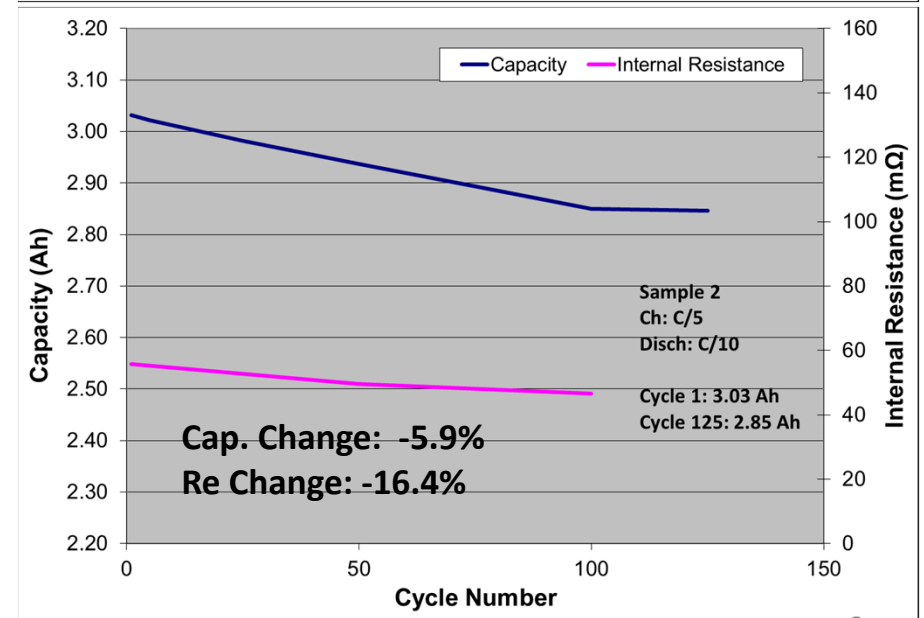
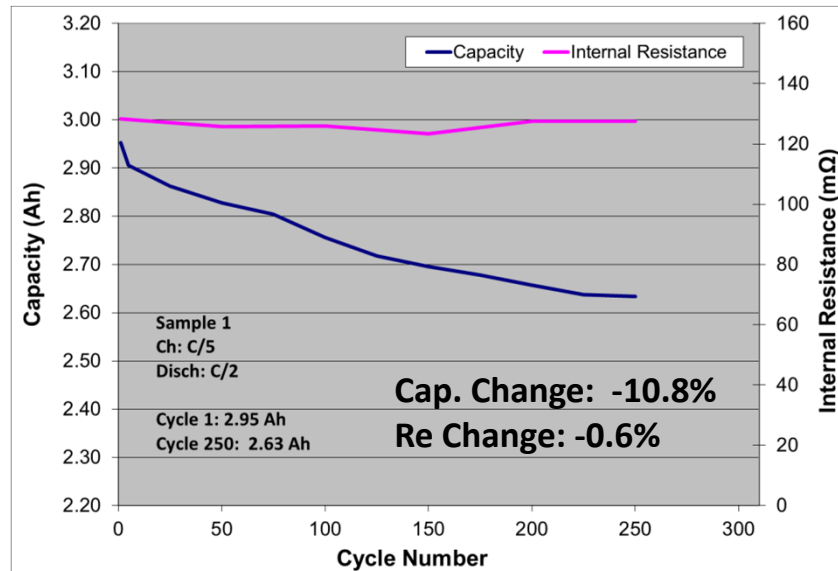
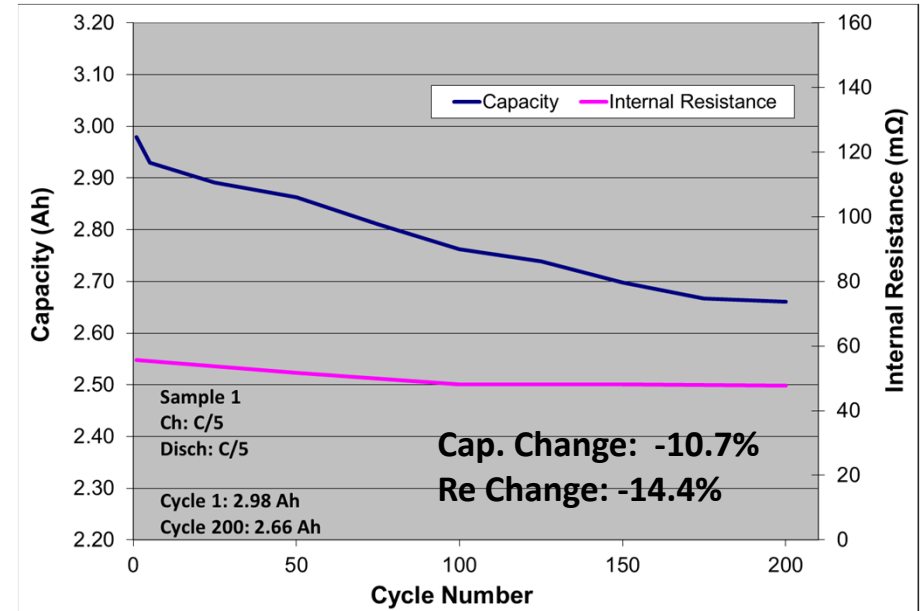
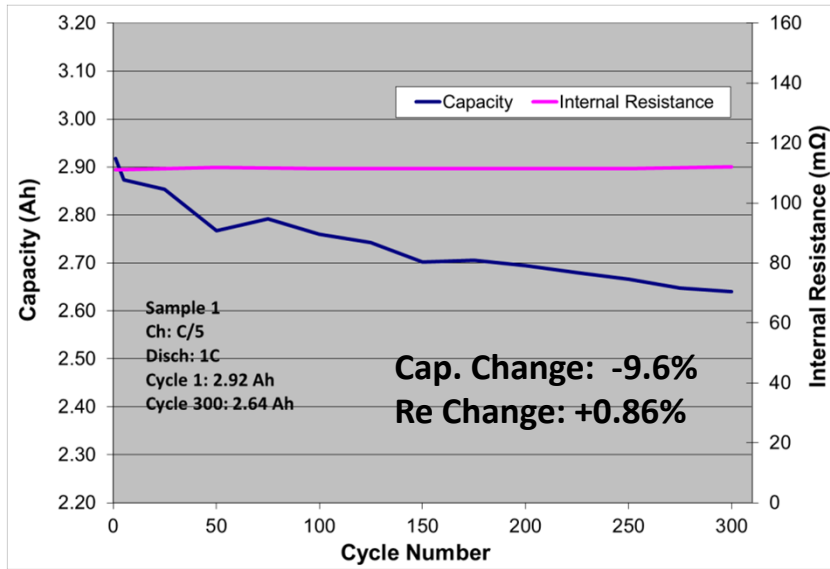
# Panasonic 3.1 Ah Li-ion 18650 Cell

## Performance and Safety Test Data

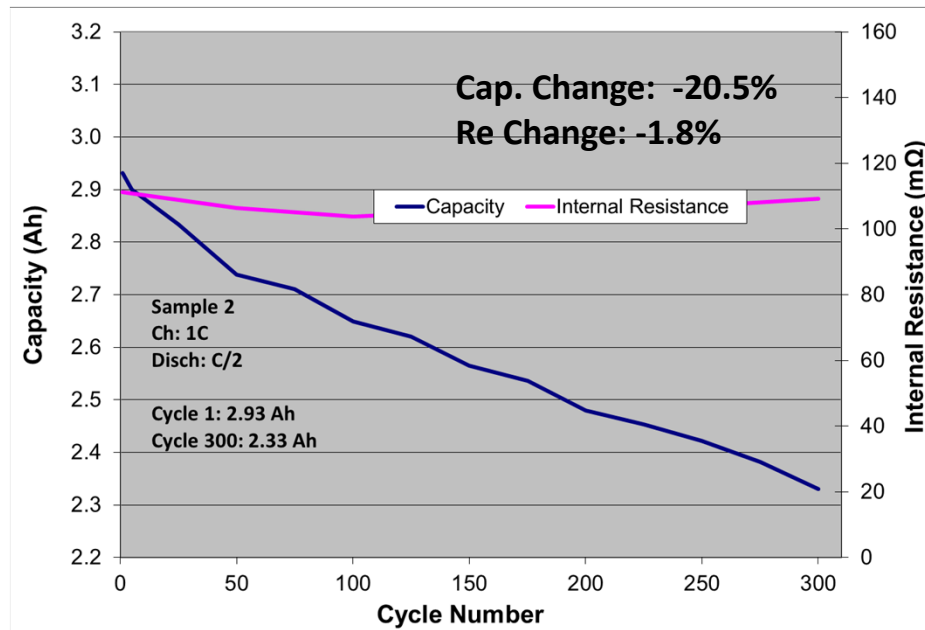
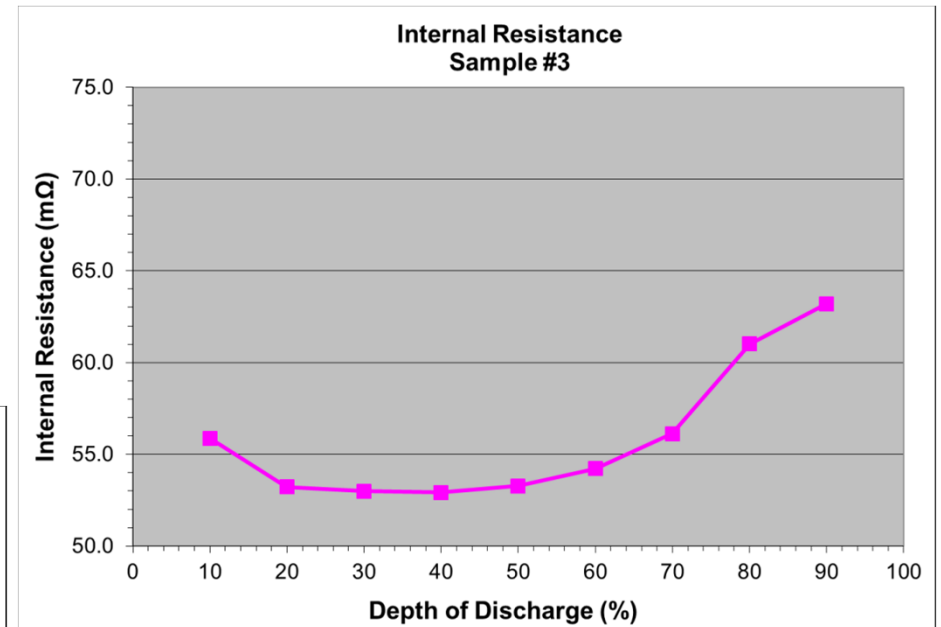
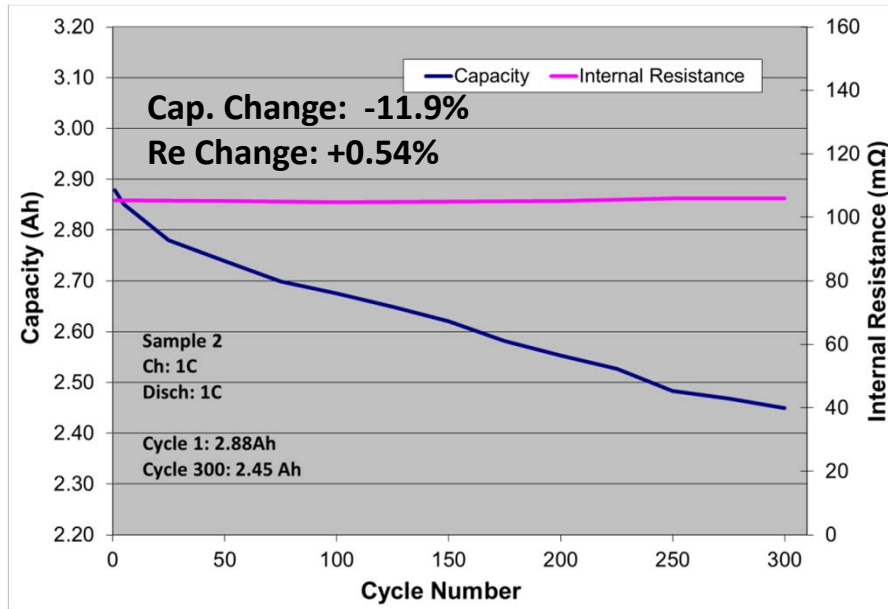
# Panasonic 3.1 Ah Li-ion 18650 Cell



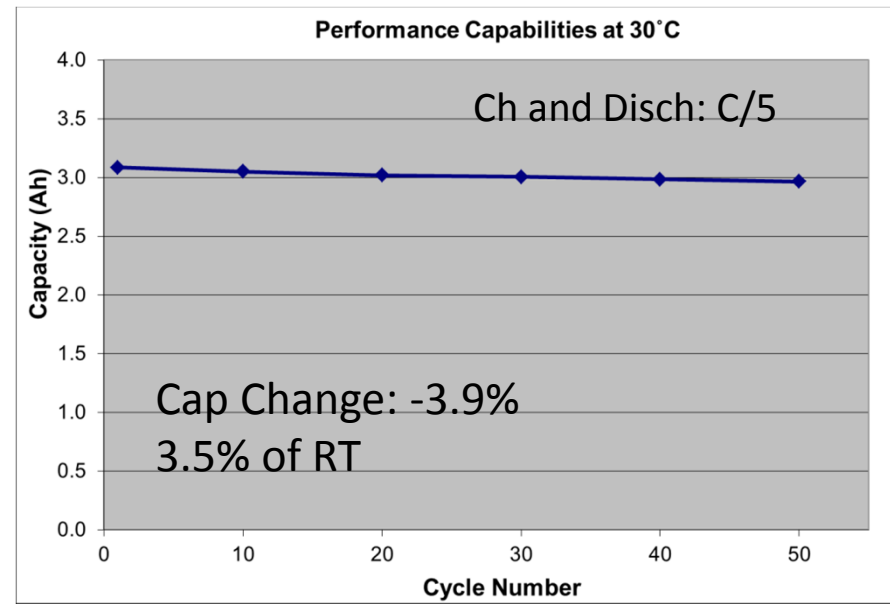
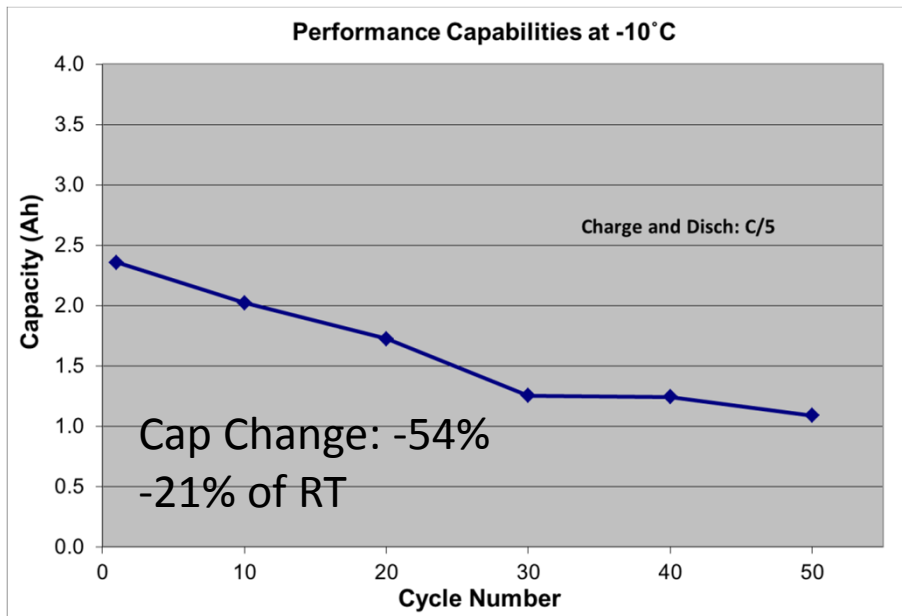
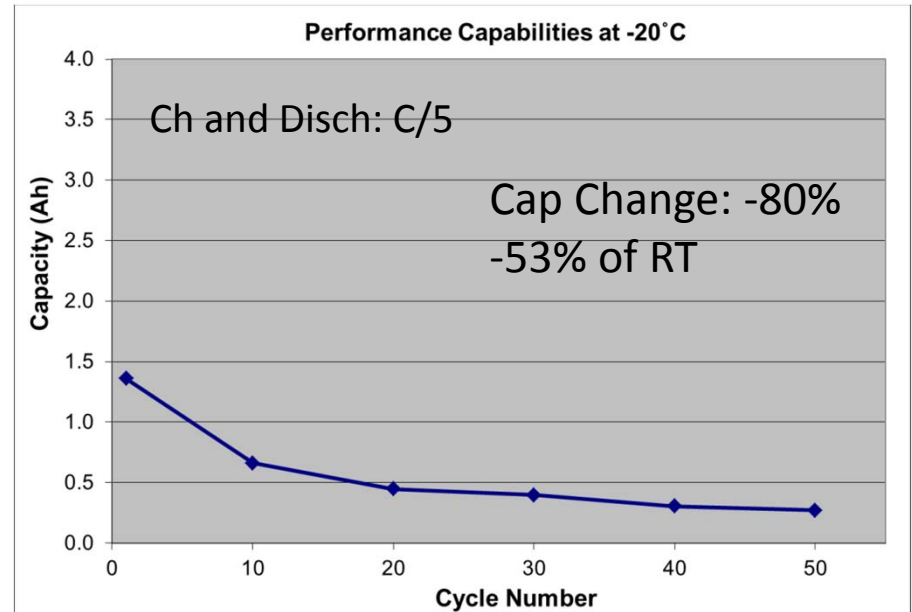
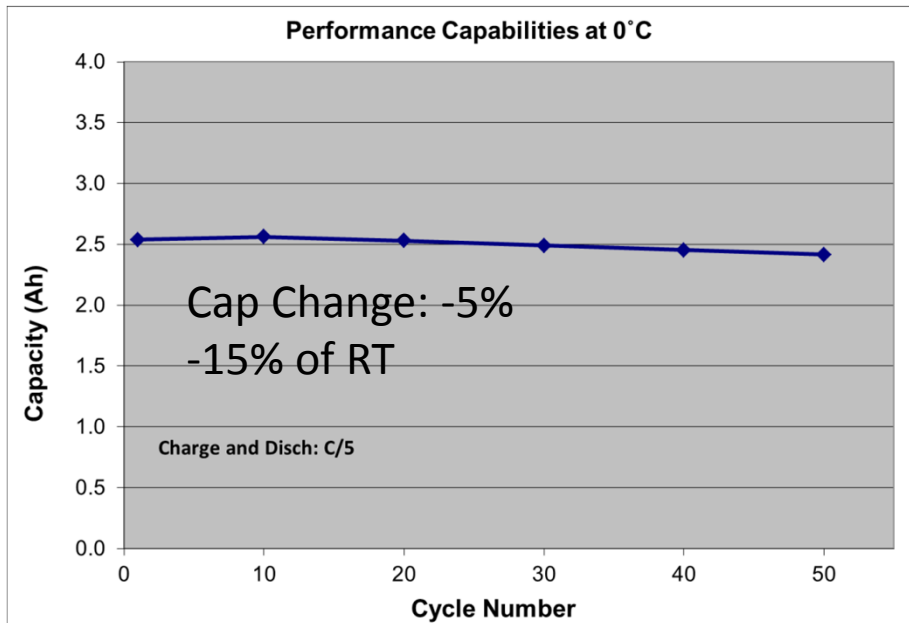
# Panasonic Li-ion 3.1 Ah 18650 Cell



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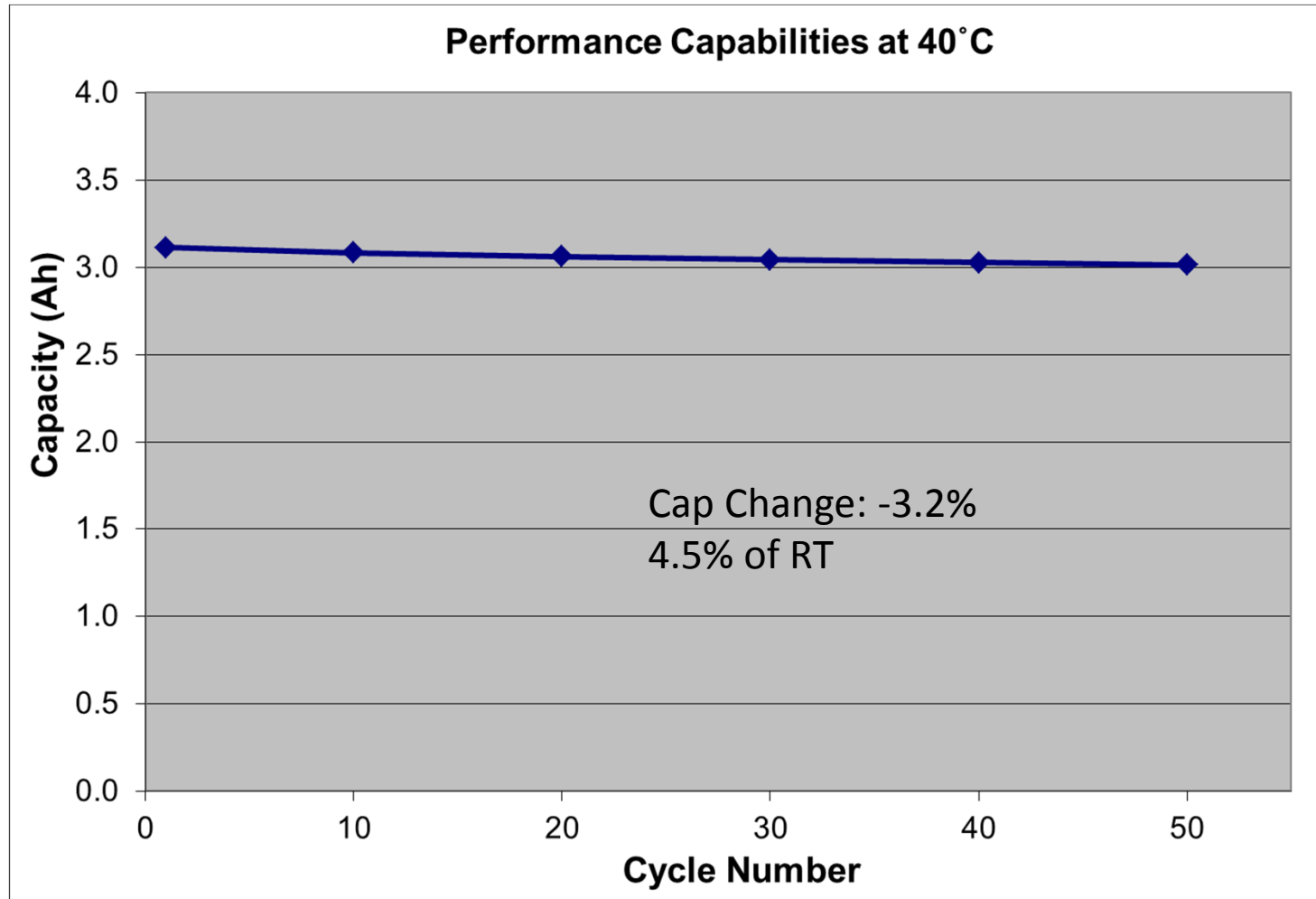


# Panasonic 3.1 Ah Li-ion 18650 Cell

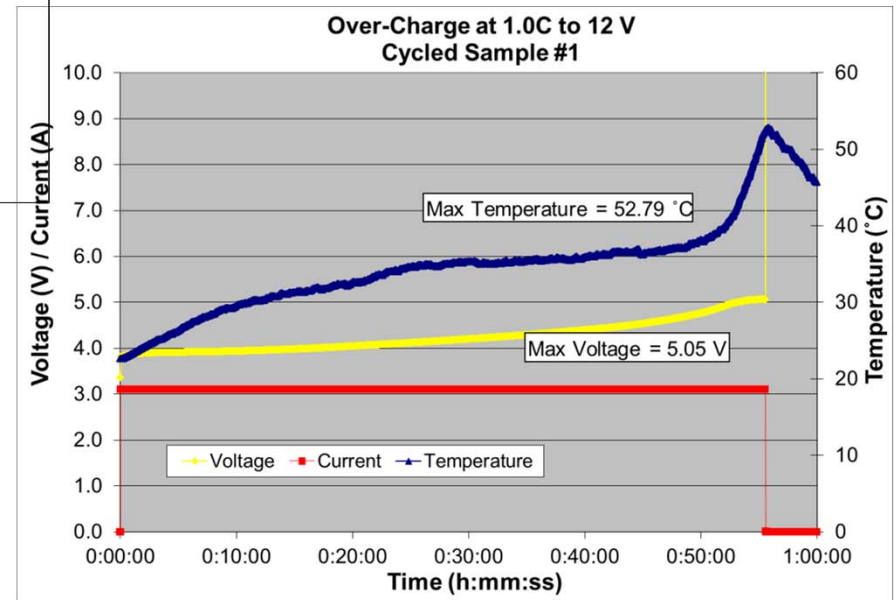
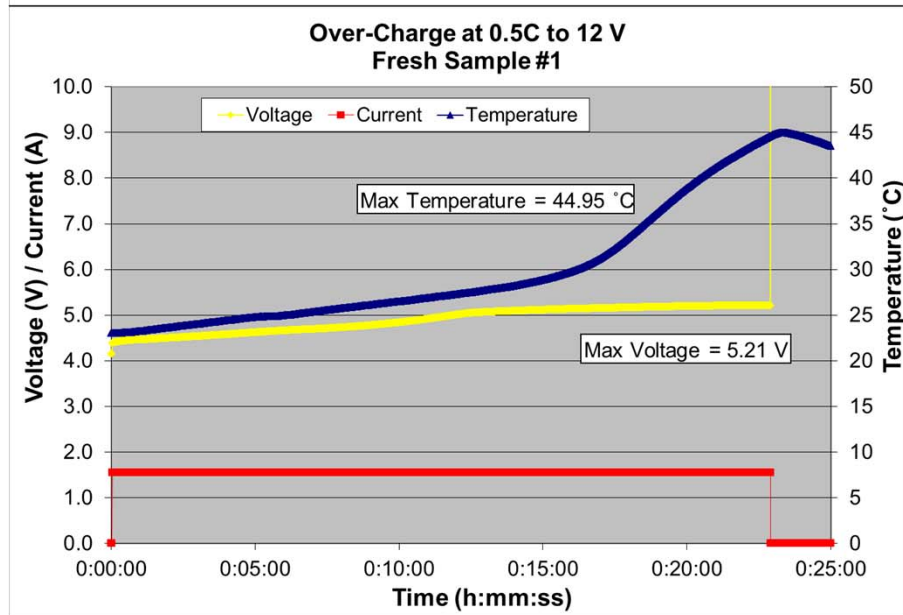
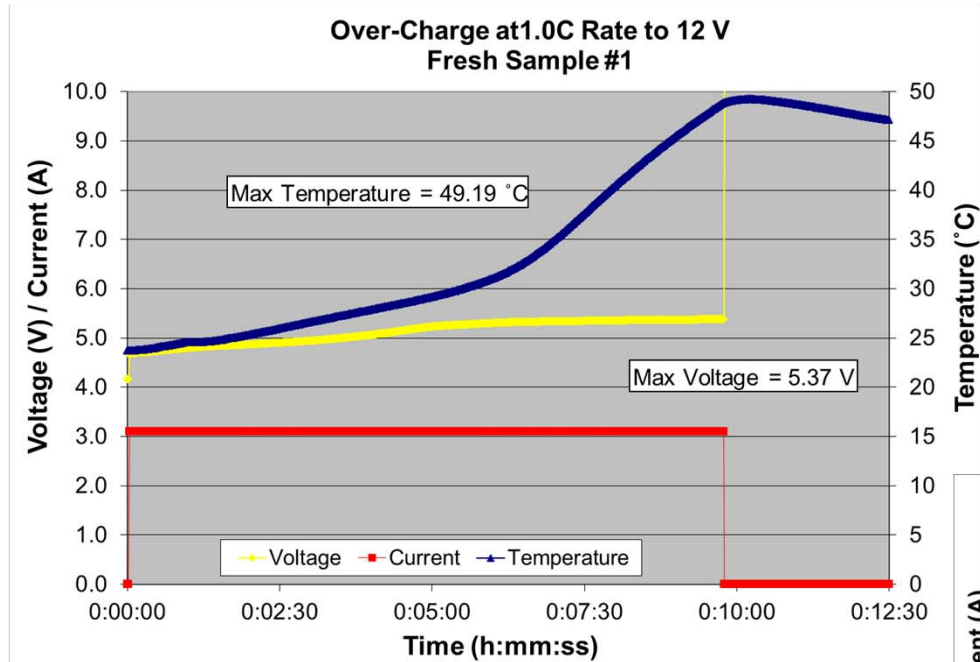




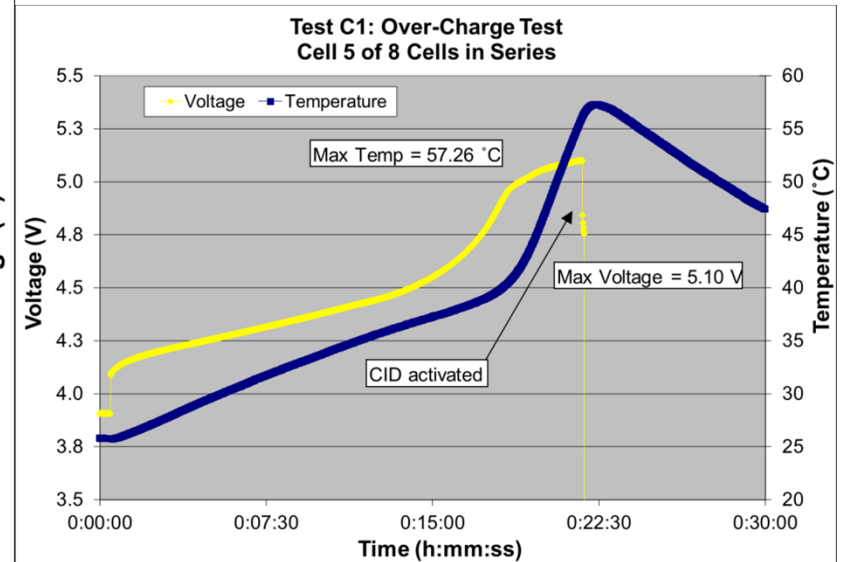
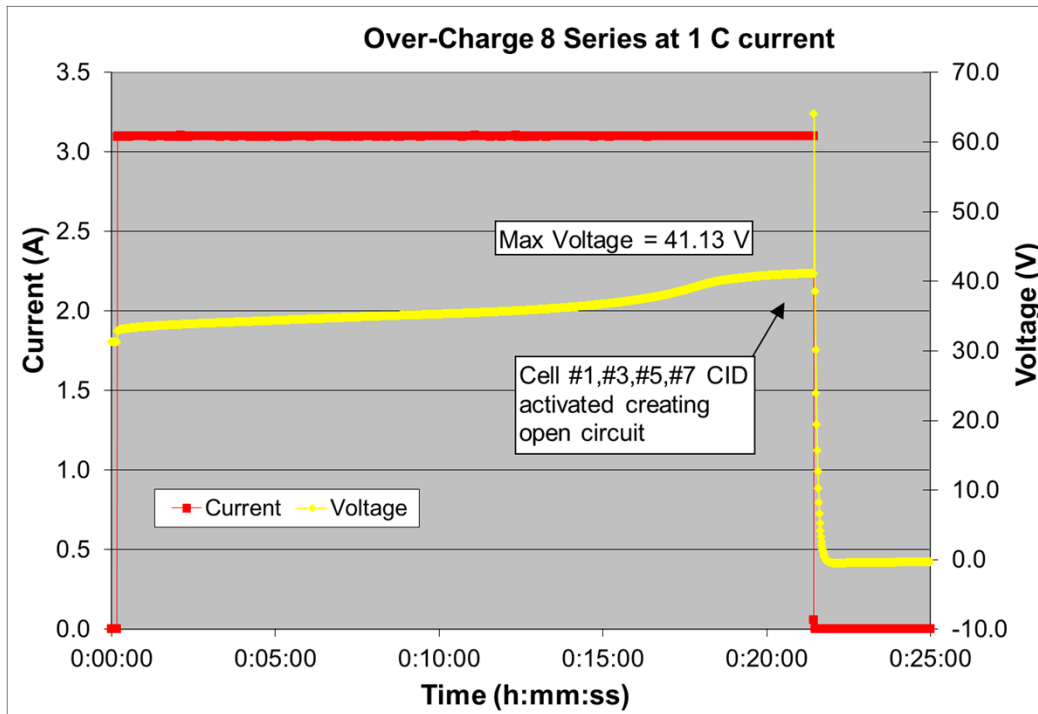
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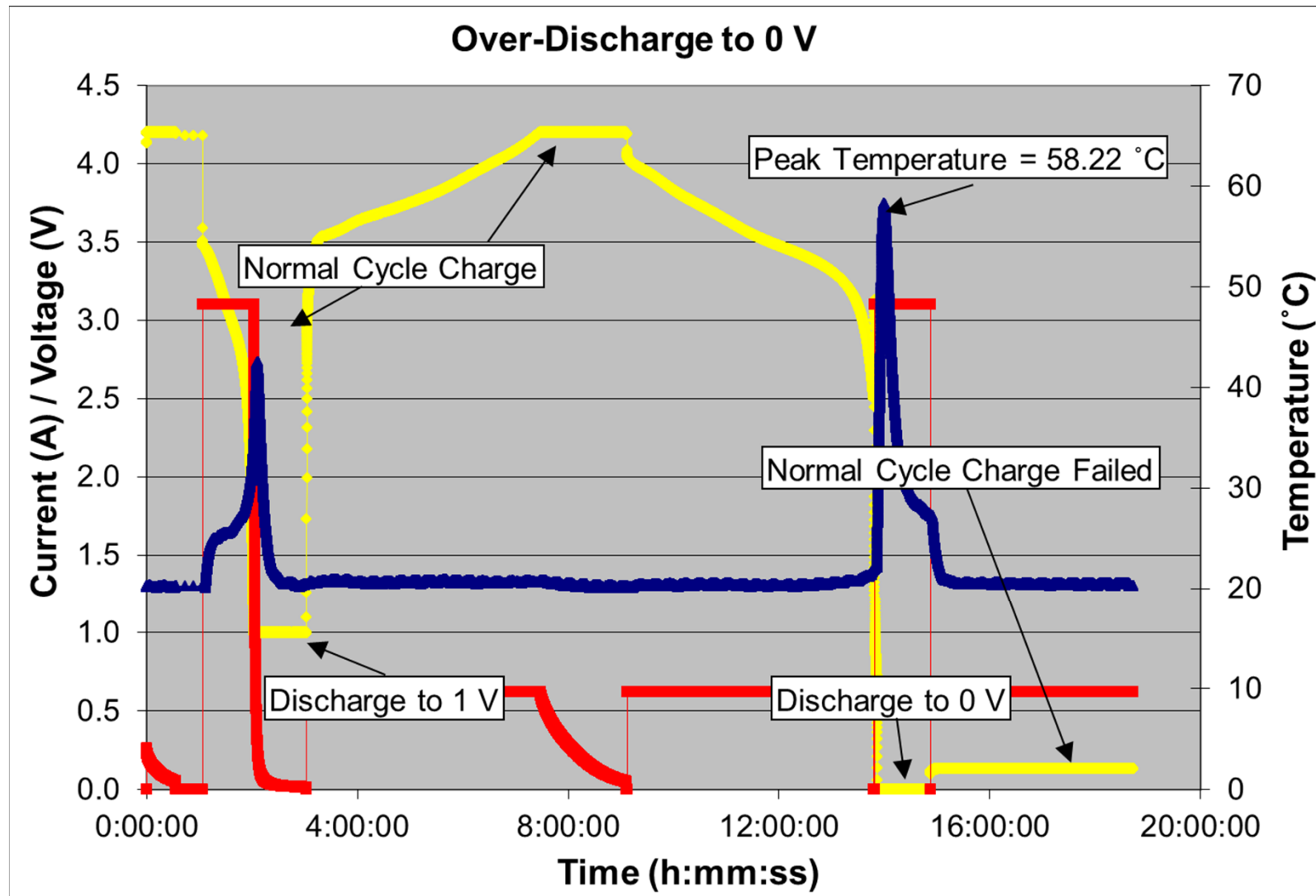
# Panasonic 3.1 Ah Li-ion 18650 Cell



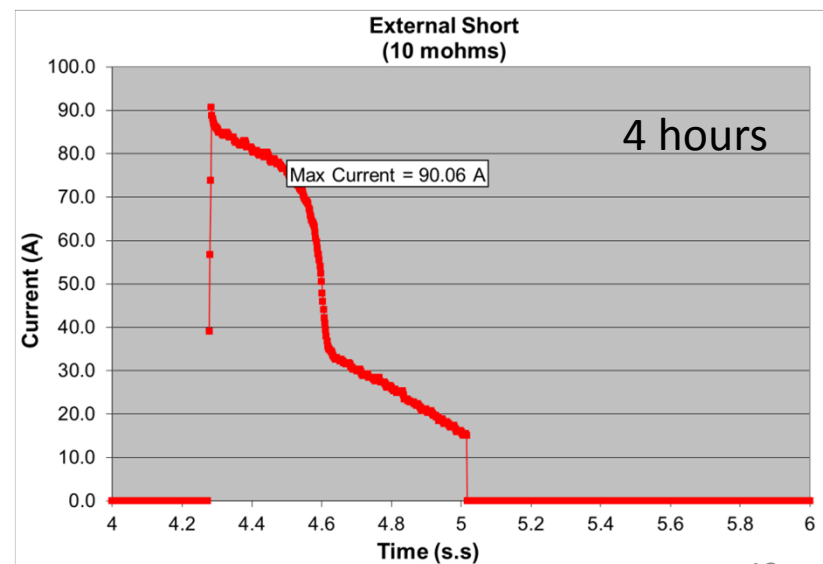
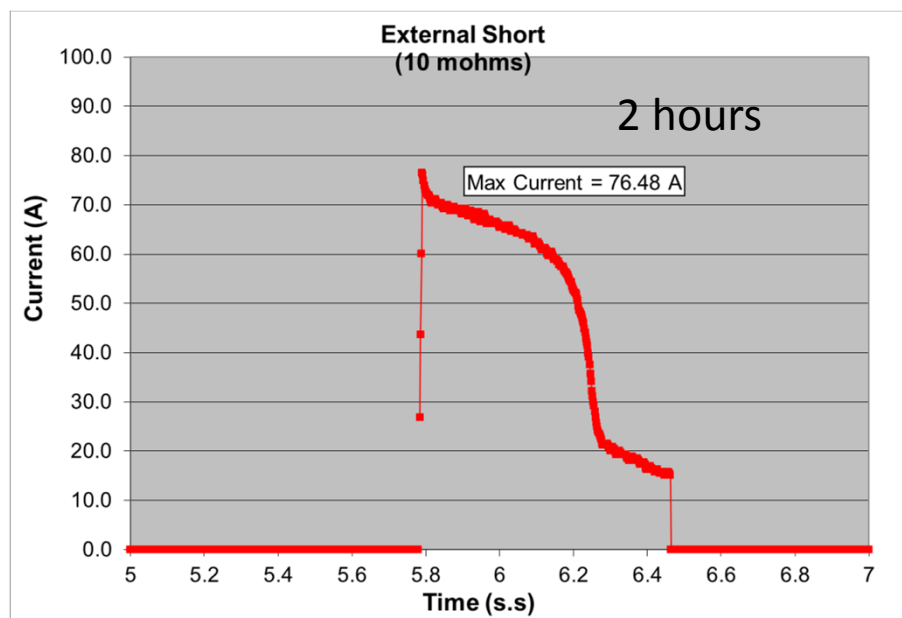
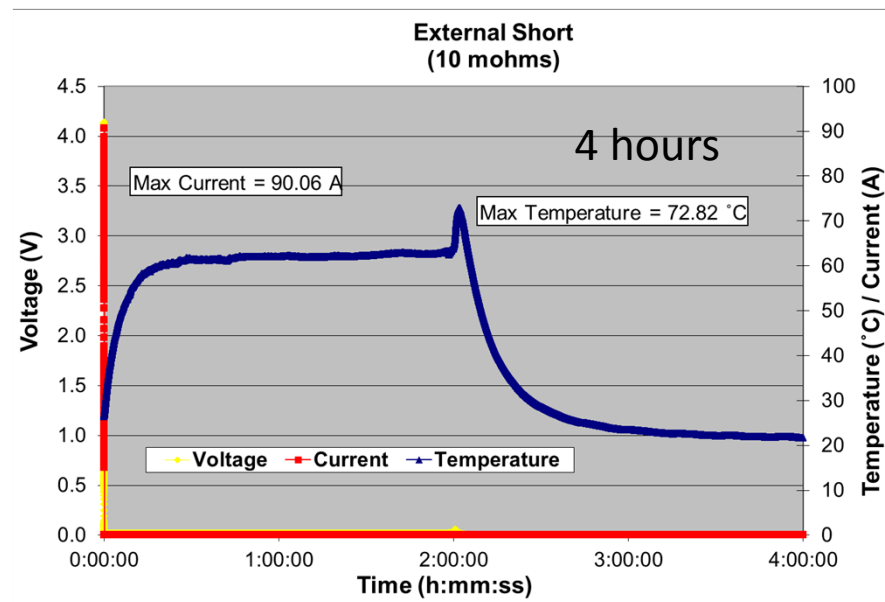
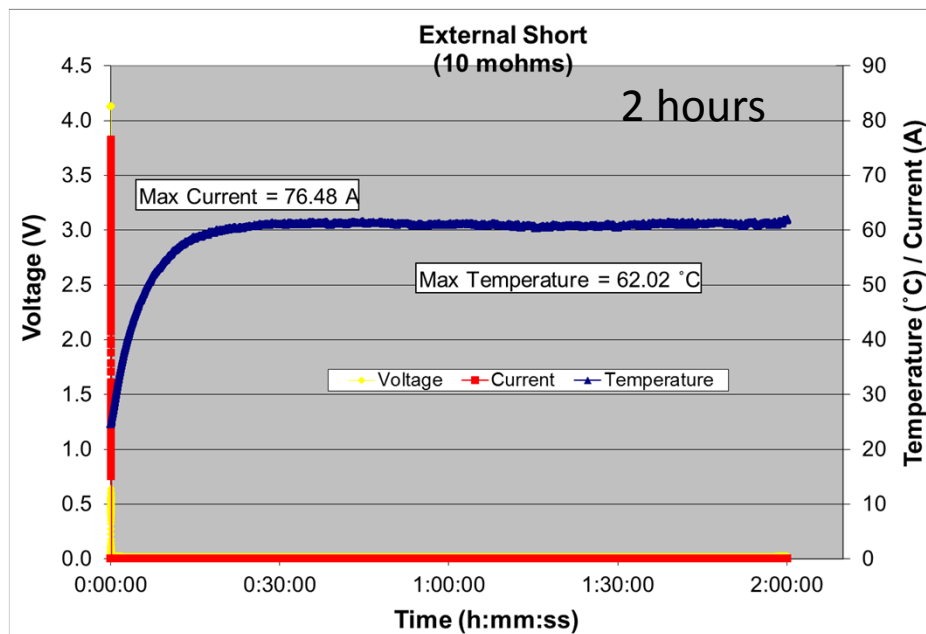
# Panasonic 3.1 Ah 18650 Li-ion Cell



# Panasonic 3.1 Ah Li-ion 18650 Cell

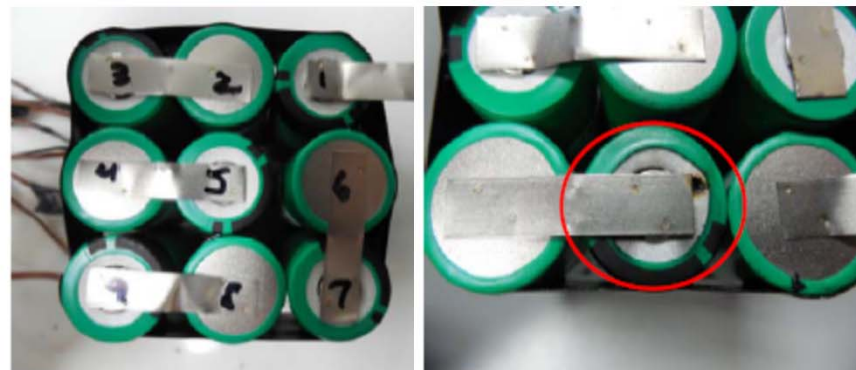


# Panasonic 3.1 Ah Li-ion 18650 Cell



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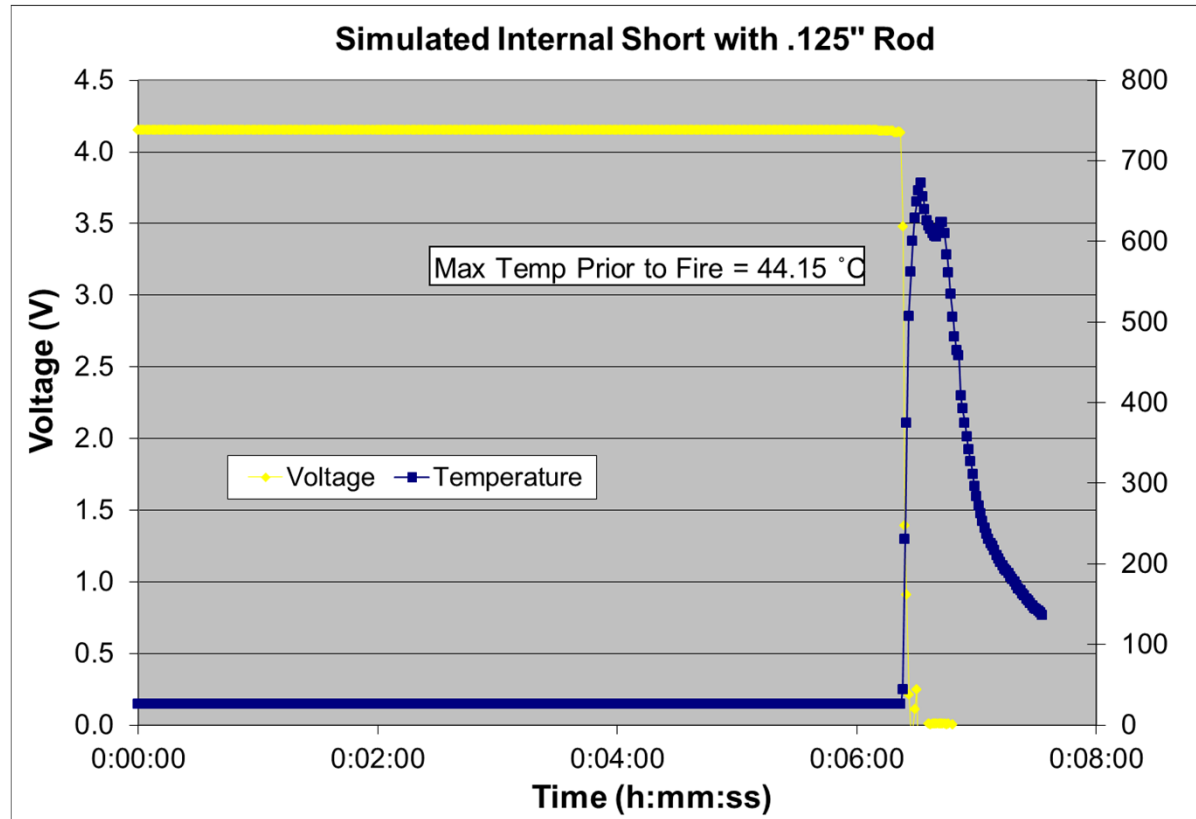
## Series String External Short (10 mohms)



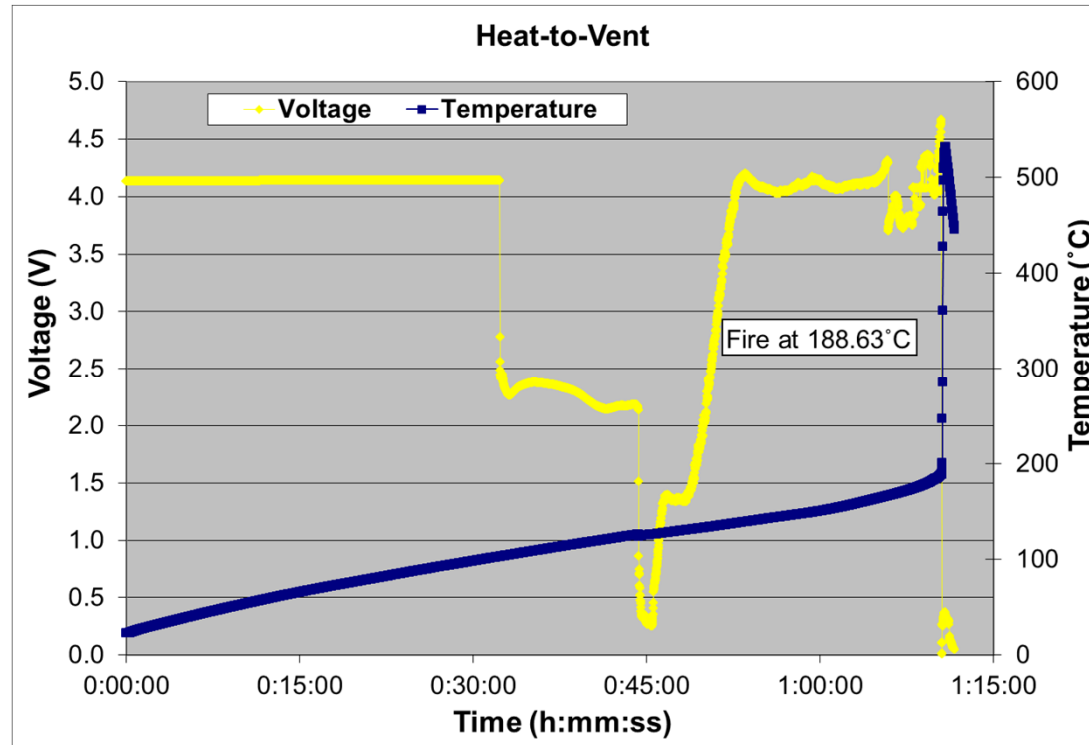
| Cell #  | Final Voltage (V) | External Resistance (mOhm) | Maximum Current (A) | Maximum Temp (°C) | Notes                                     |
|---------|-------------------|----------------------------|---------------------|-------------------|-------------------------------------------|
| 1       | 4.05              | -                          | -                   | 23.57             | No vent or fire                           |
| 2       | 4.04              | -                          | -                   | 24.83             | No vent or fire                           |
| 3       | 4.05              | -                          | -                   | 26.43             | Smoked, no fire, burn mark on cathode tab |
| 4       | 4.04              | -                          | -                   | 24.84             | No vent or fire                           |
| 5       | 4.05              | -                          | -                   | 26.73             | No vent or fire                           |
| 6       | 4.05              | -                          | -                   | 37.68             | No vent or fire                           |
| 7       | 0.00              | -                          | -                   | 56.27             | No vent or fire                           |
| 8       | 4.05              | -                          | -                   | 38.36             | No vent or fire                           |
| Overall | -                 | 9.7                        | 92.13               | -                 | No vent or fire                           |

| Cell #  | Final Voltage (V) | External Resistance (mOhm) | Maximum Current (A) | Maximum Temp (°C) | Notes                                     |
|---------|-------------------|----------------------------|---------------------|-------------------|-------------------------------------------|
| 1       | 3.95              | -                          | -                   | 31.60             | No vent or fire                           |
| 2       | 3.95              | -                          | -                   | 32.73             | No vent or fire                           |
| 3       | 3.95              | -                          | -                   | 30.96             | No vent or fire                           |
| 4       | 3.95              | -                          | -                   | 31.04             | No vent or fire                           |
| 5       | 3.95              | -                          | -                   | 35.15             | No vent or fire                           |
| 6       | 3.94              | -                          | -                   | 42.42             | No vent or fire                           |
| 7       | 0.00              | -                          | -                   | 45.43             | No vent or fire                           |
| 8       | 3.94              | -                          | -                   | 38.63             | Smoked, no fire, burn mark on cathode tab |
| 9       | 3.95              | -                          | -                   | 31.12             | No vent or fire                           |
| Overall | -                 | 9.7                        | 89.45               | -                 | No vent or fire                           |

# Panasonic 3.1 Ah Li-ion 18650 Cell



# Panasonic 3.1 Ah Li-ion 18650 Cell

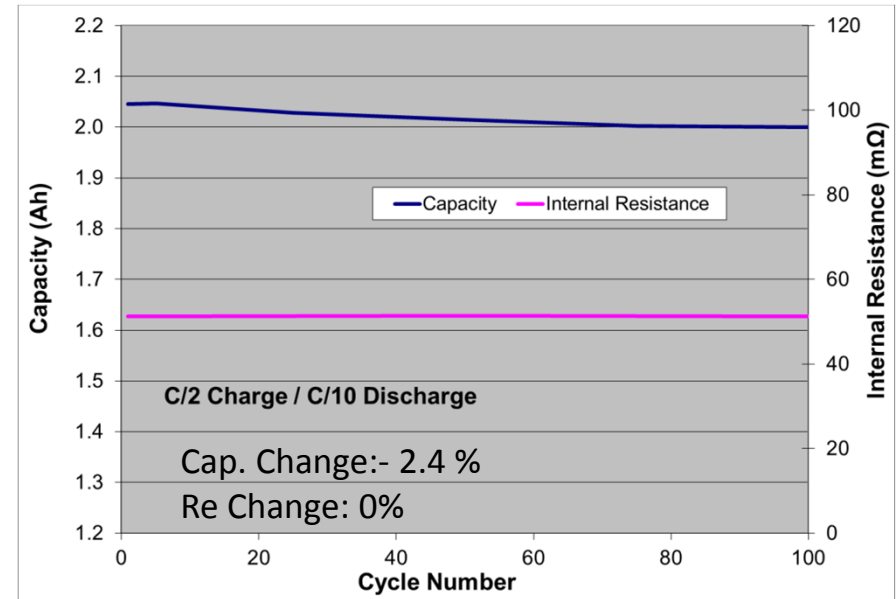
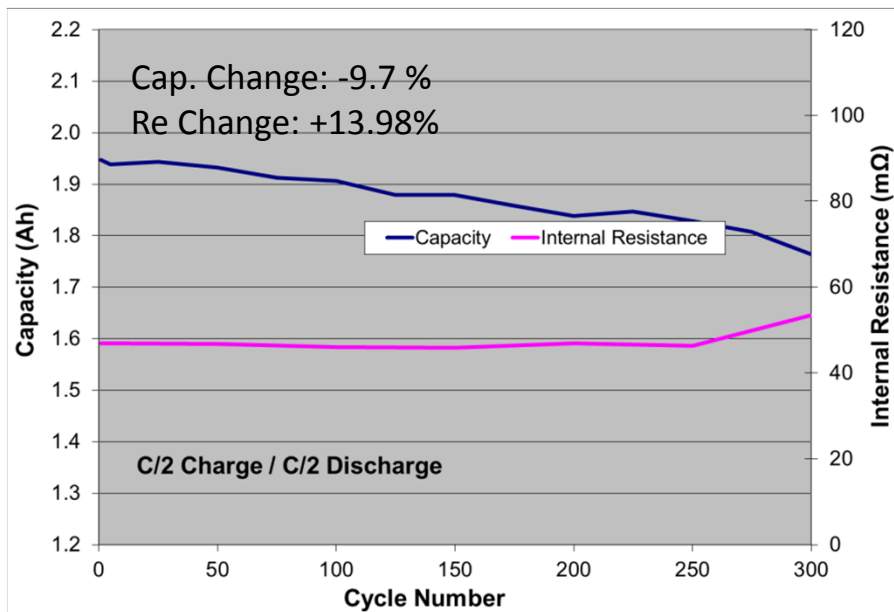
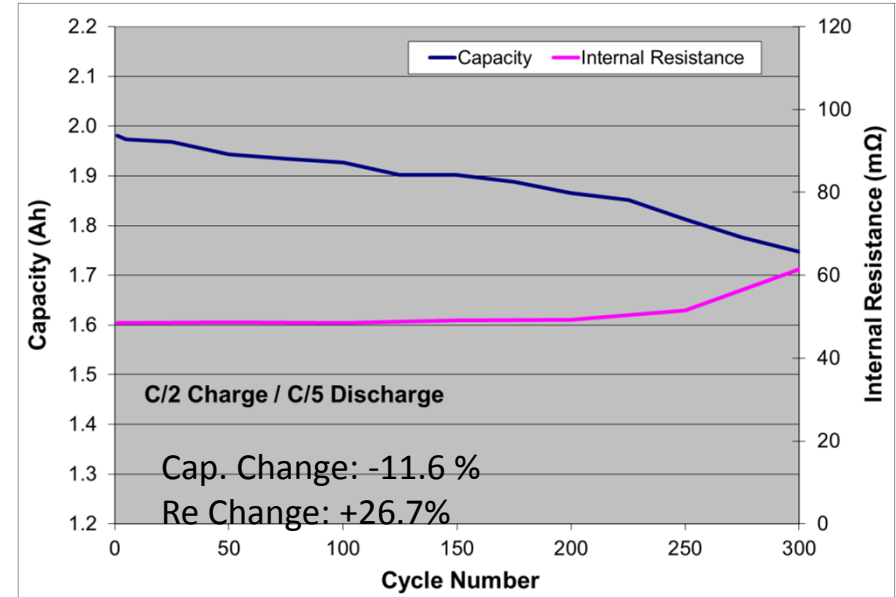
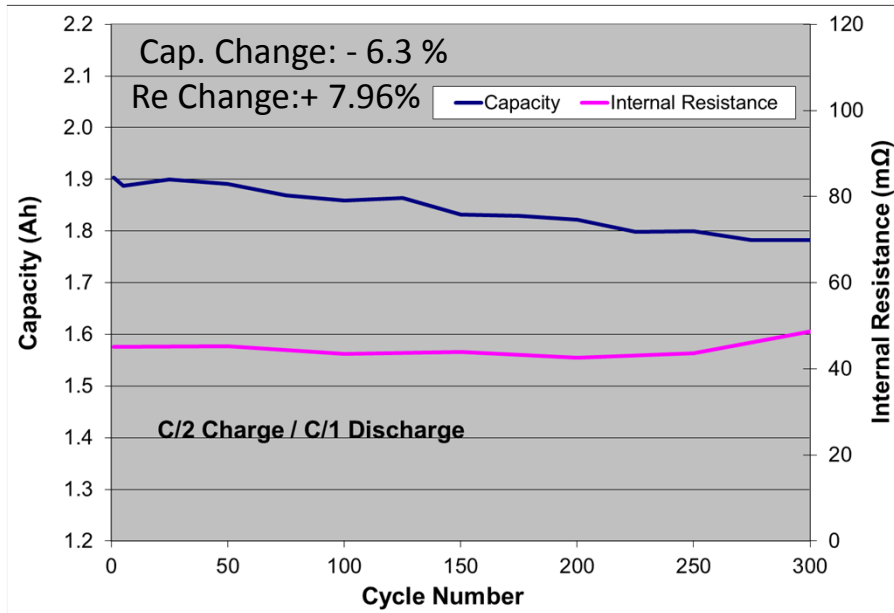




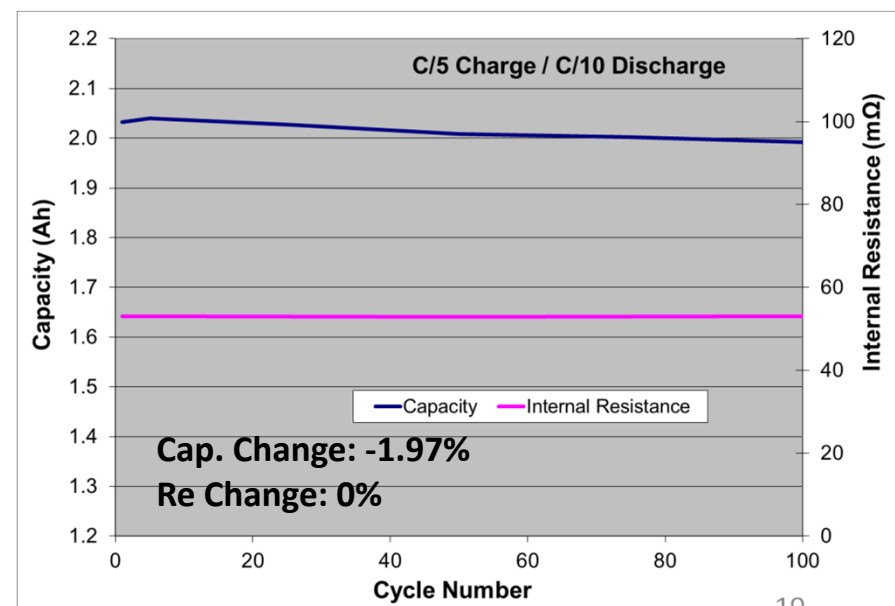
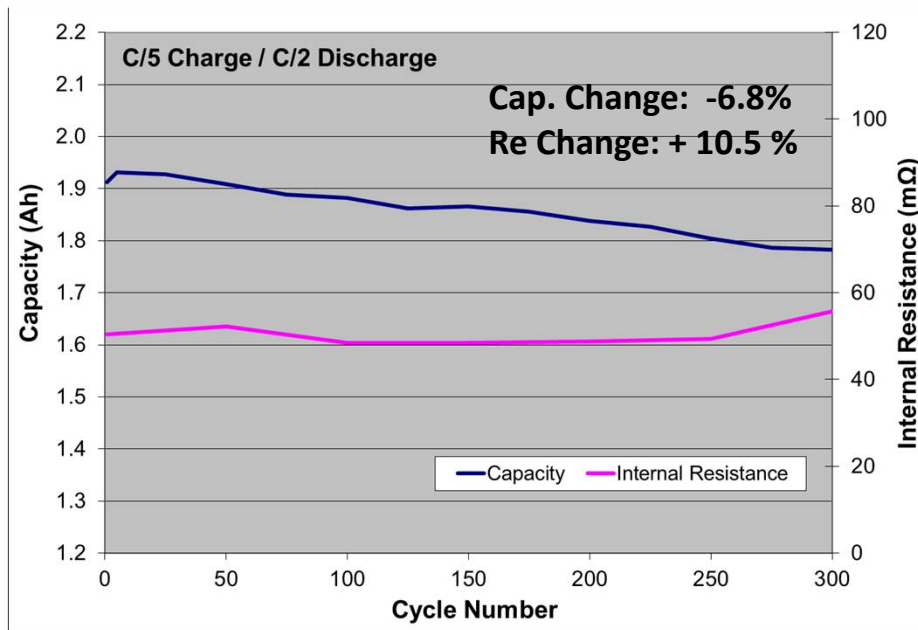
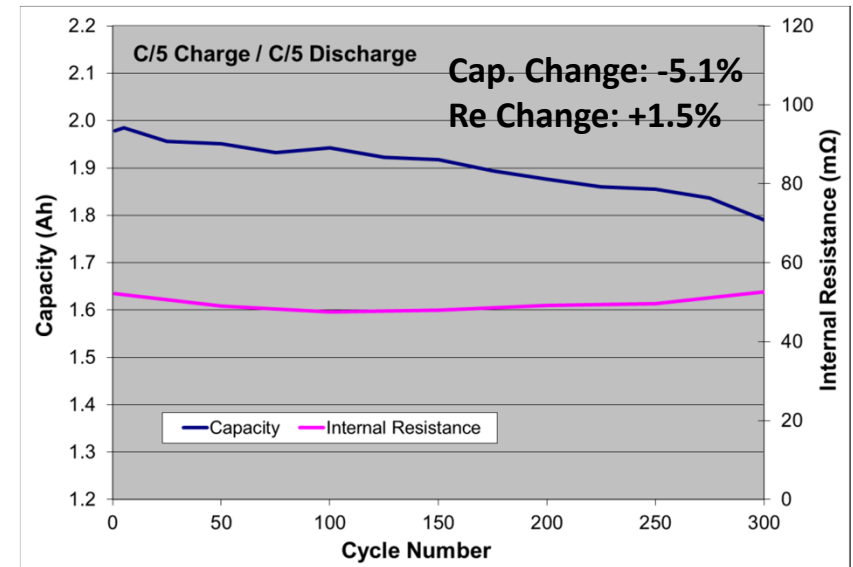
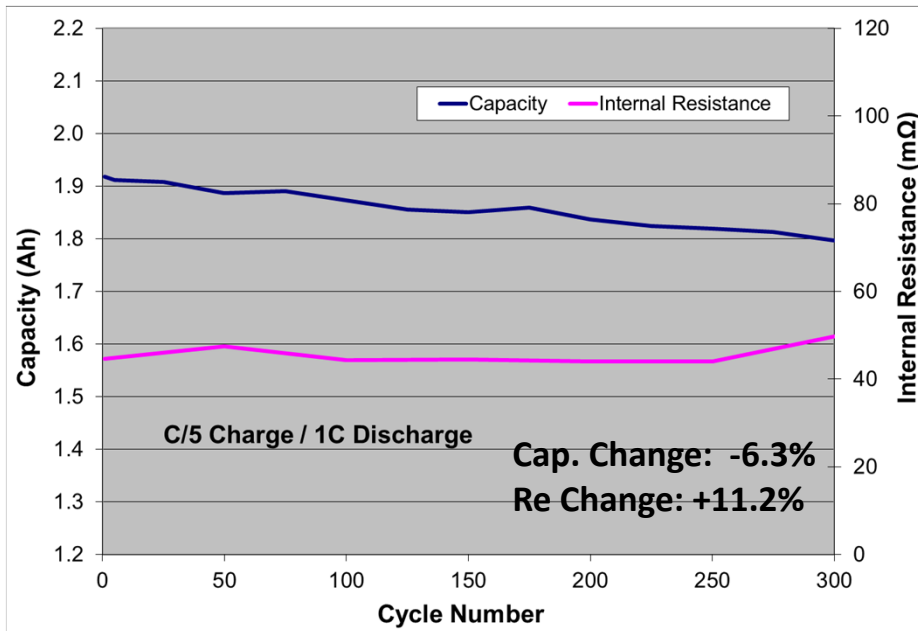
# Moli STOBA 2.0 Ah Li-ion 18650 Cell

## Performance and Safety Test Data

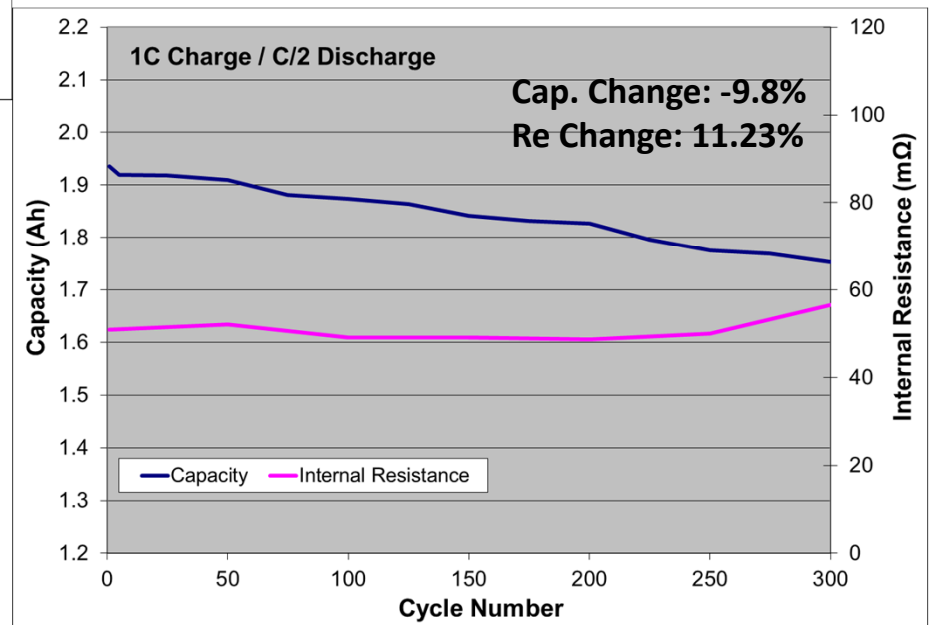
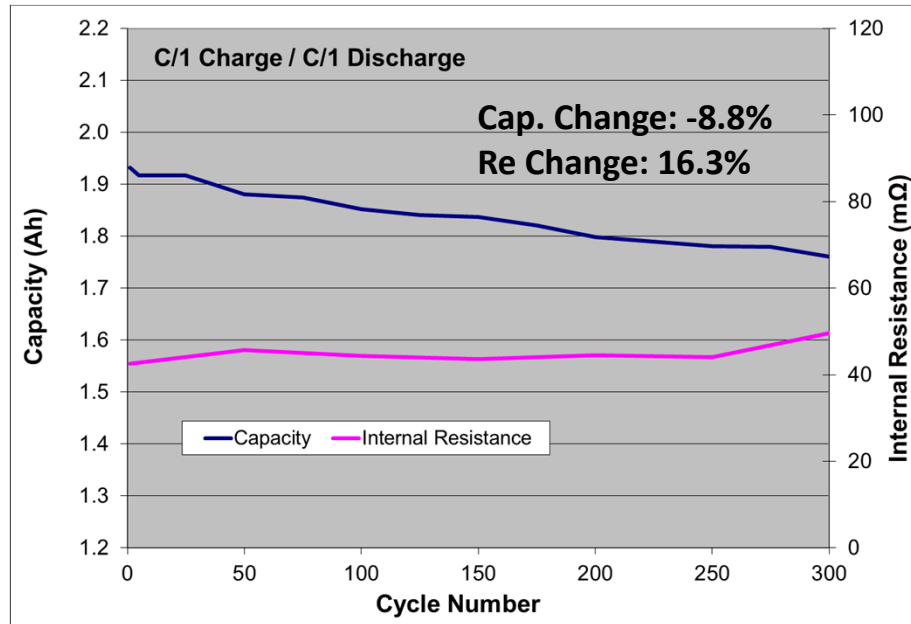
# Moli STOBA 2.0 Ah Li-ion Cell



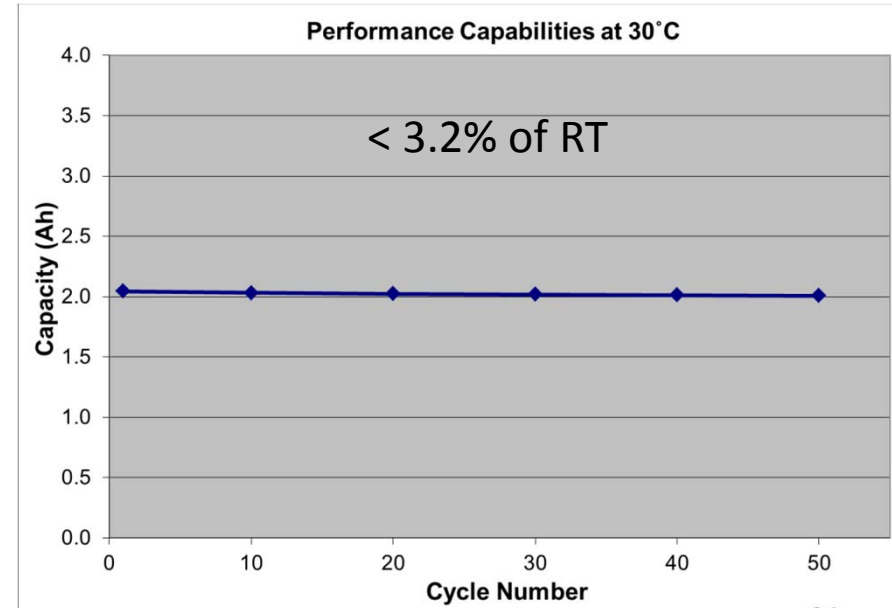
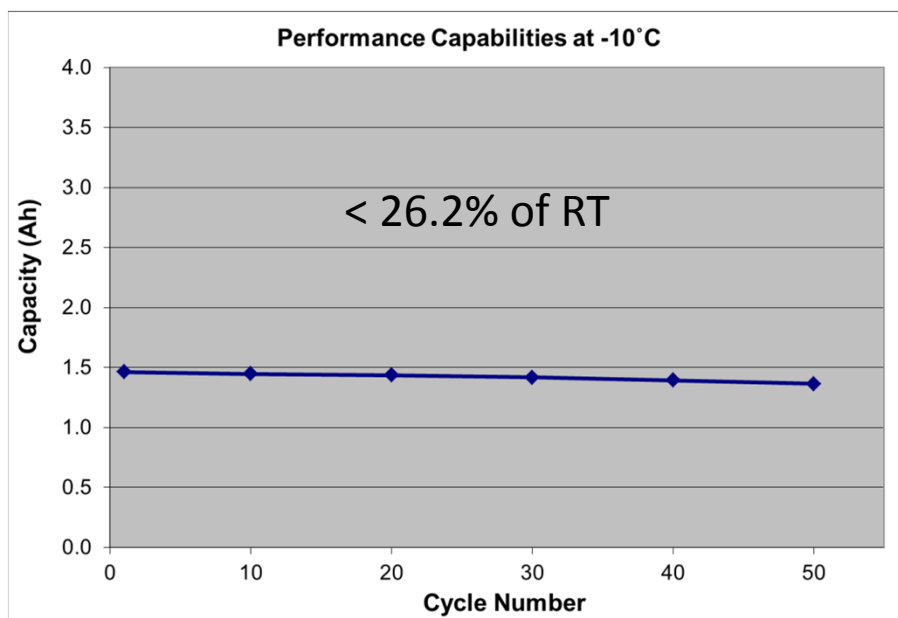
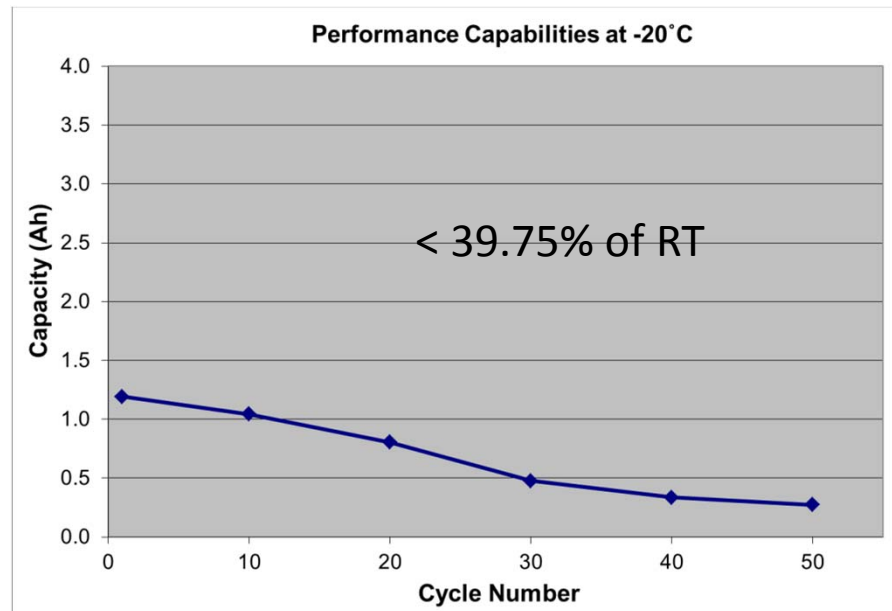
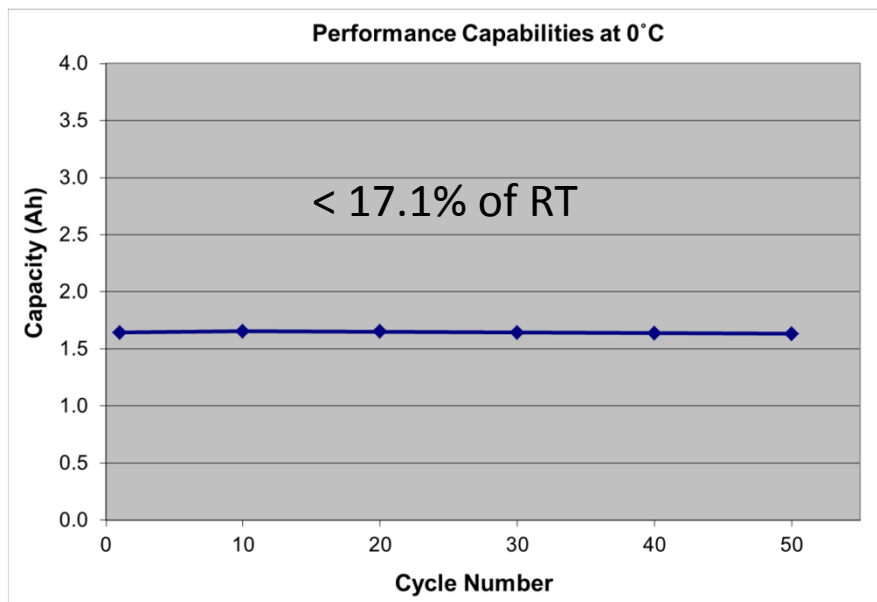
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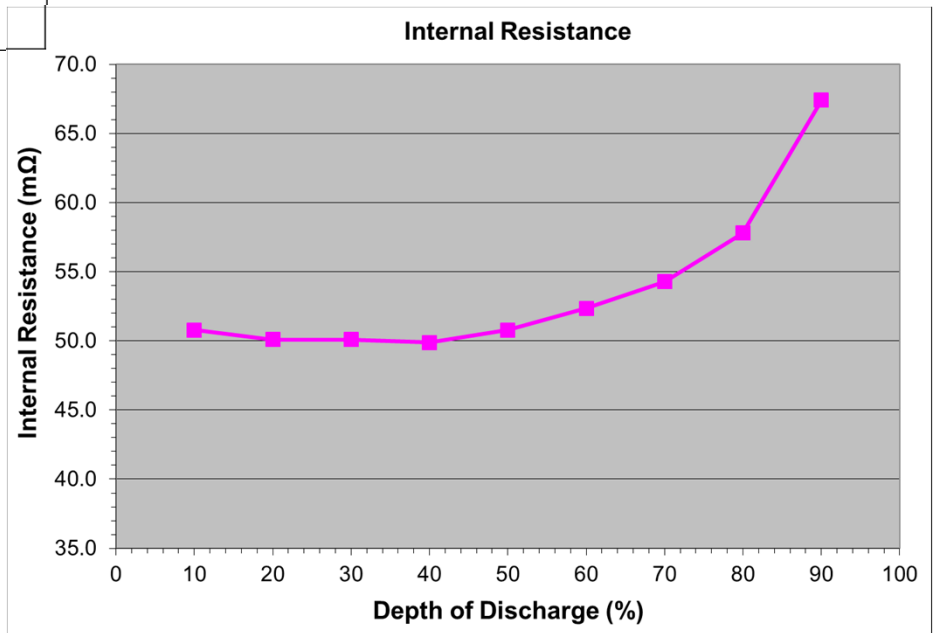
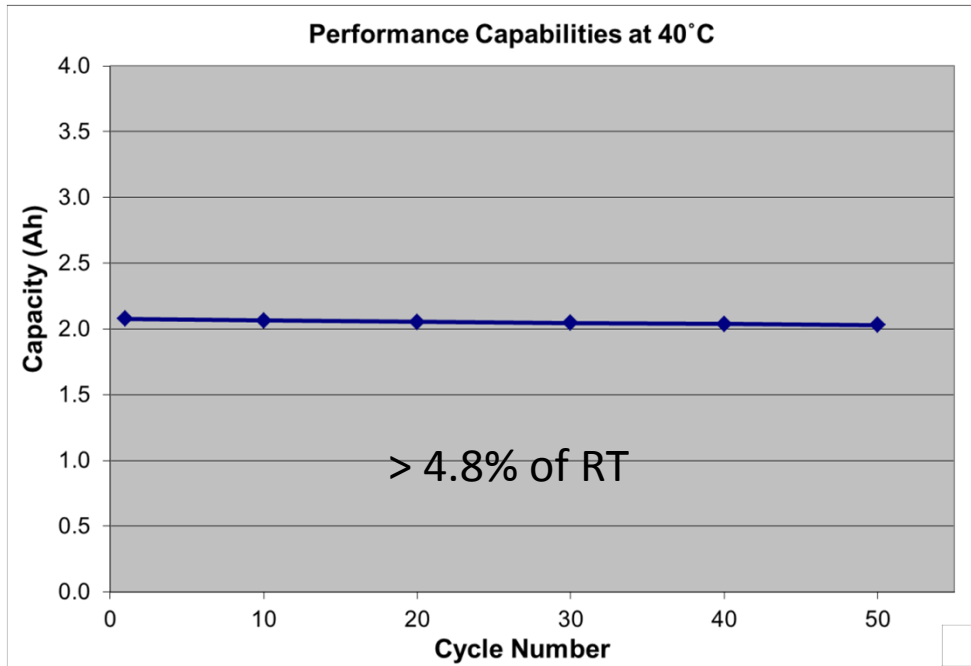
# Moli STOBA 2.0 Ah Li-ion Cell



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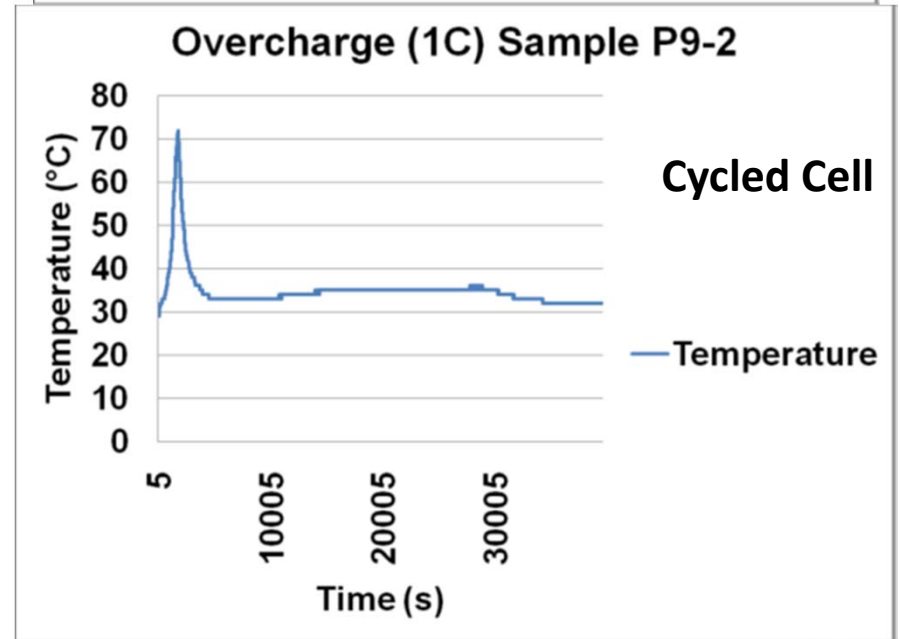
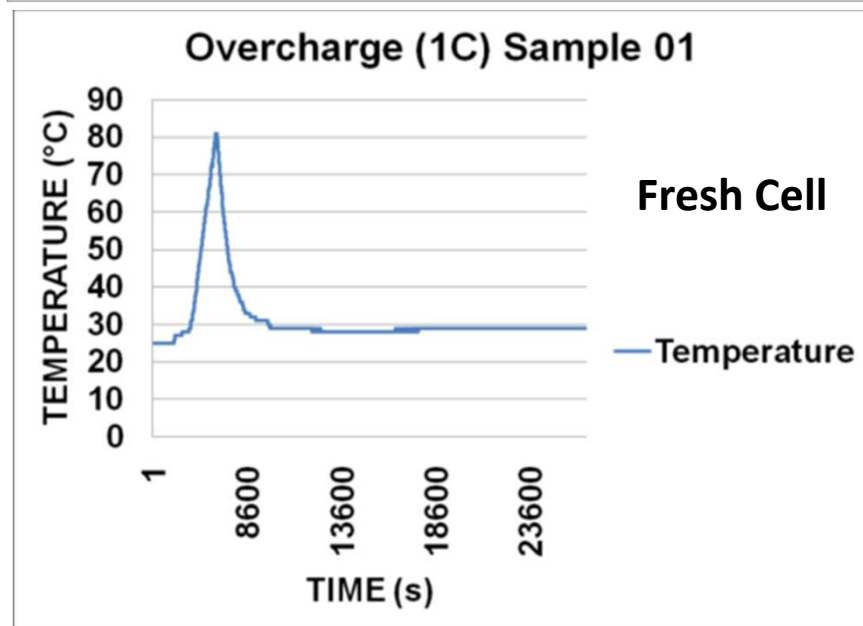
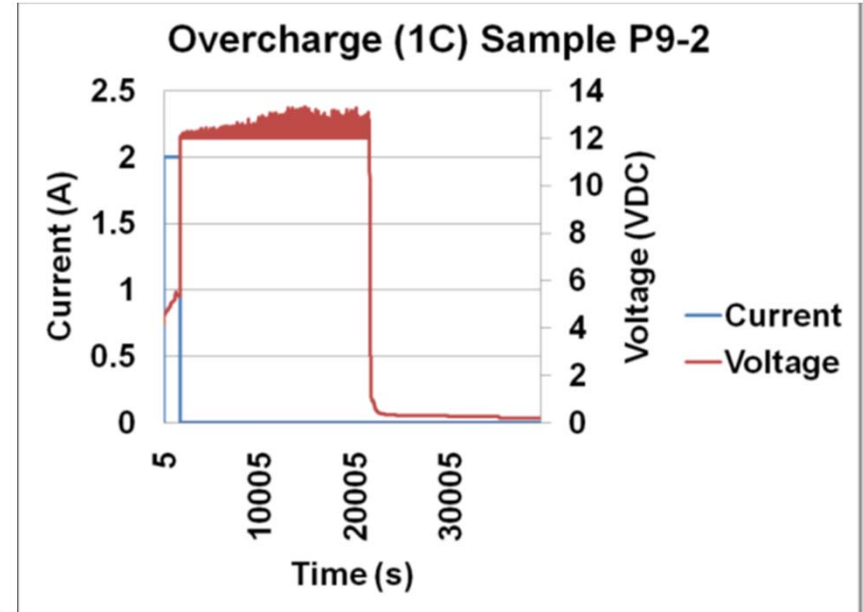
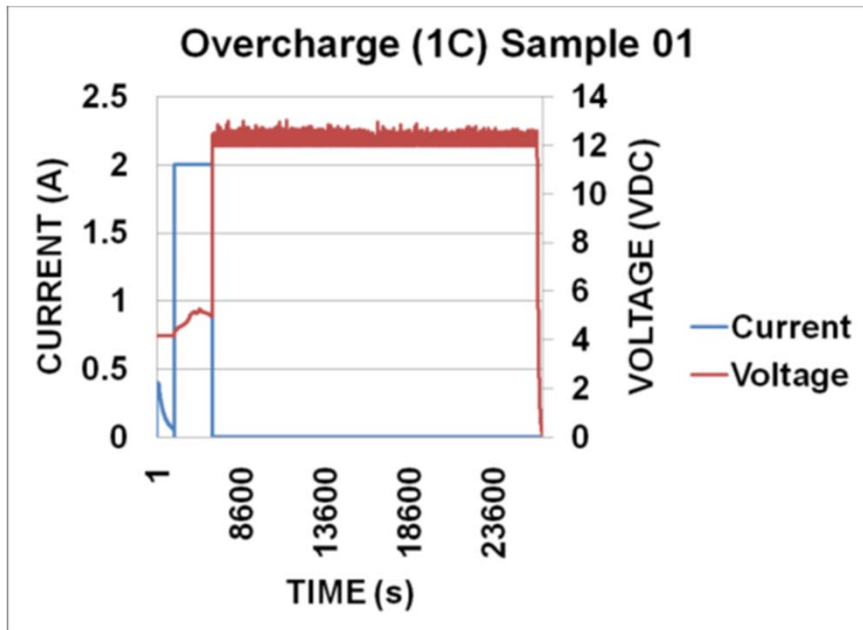
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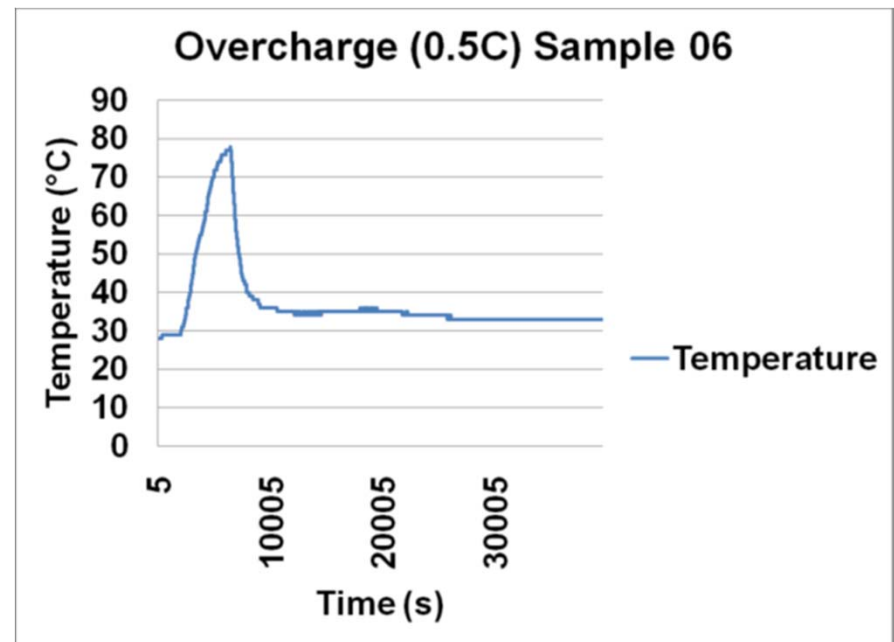
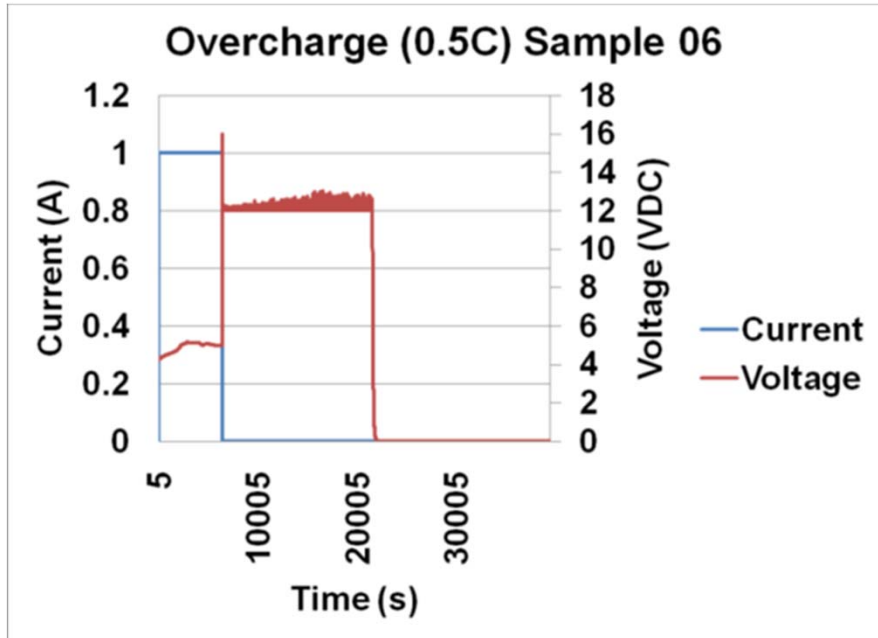
# Moli STOBA 2.0 Ah Li-ion Cell

Fresh Cell

Cycled Cell



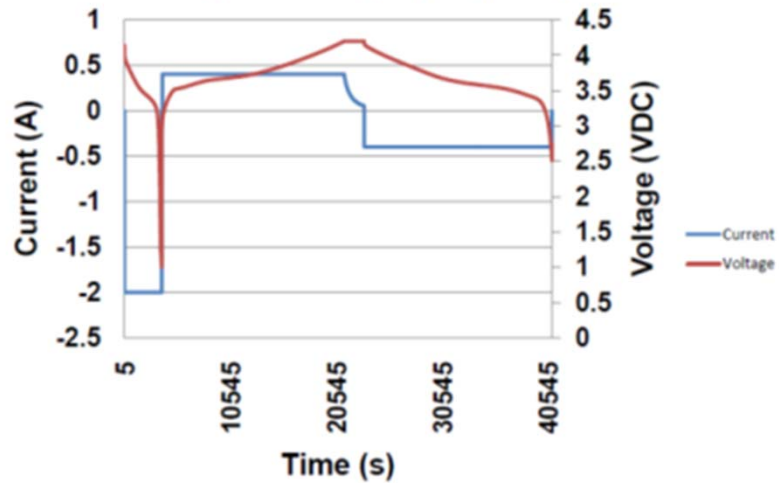
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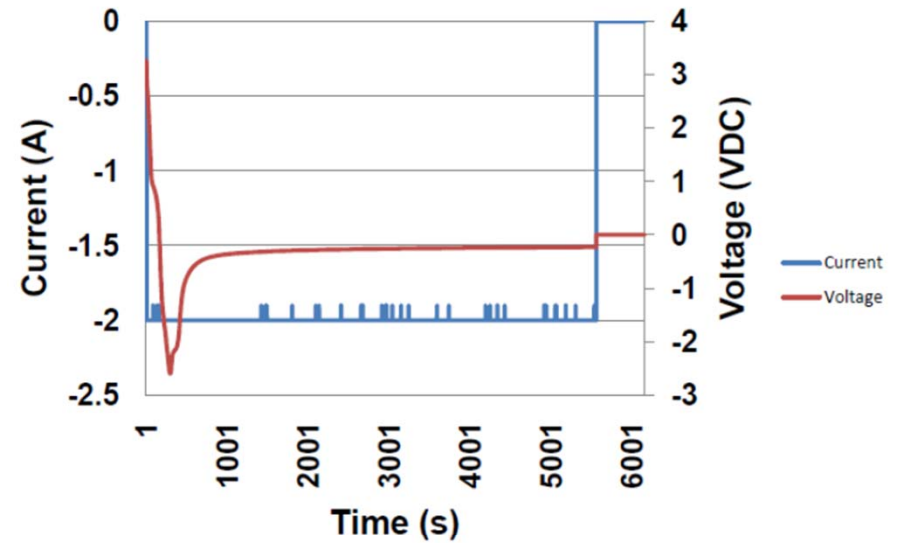


# Moli ST0BA 2.0 Ah Li-ion Cell

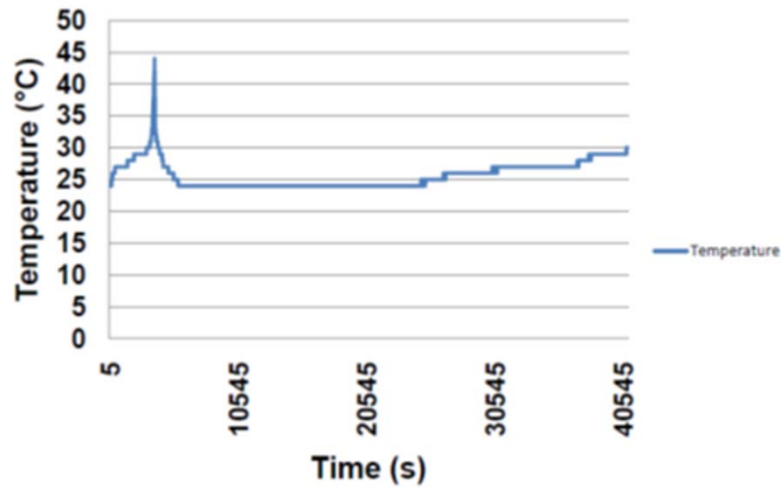
Overdischarge (Discharge to 1 VDC & Charge-Discharge Cycle) Sample 16



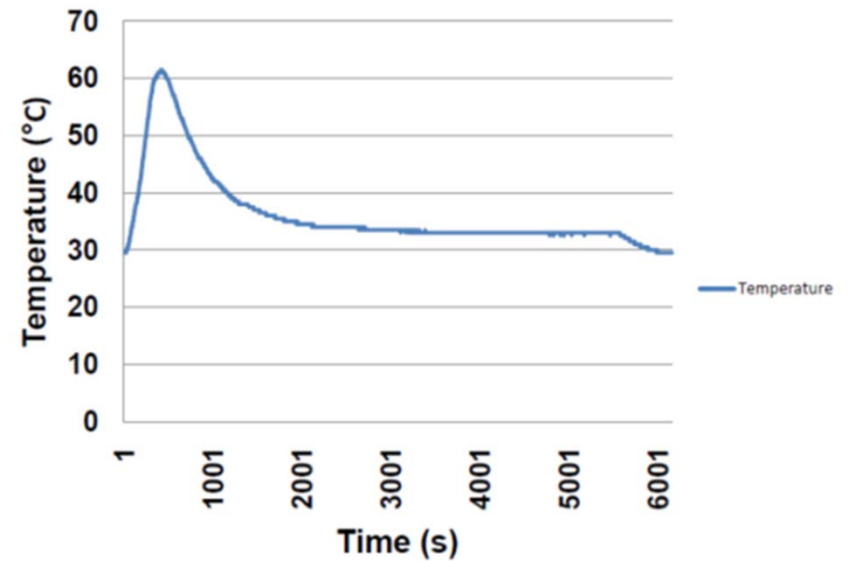
Overdischarge (Voltage Reversal) Sample 16



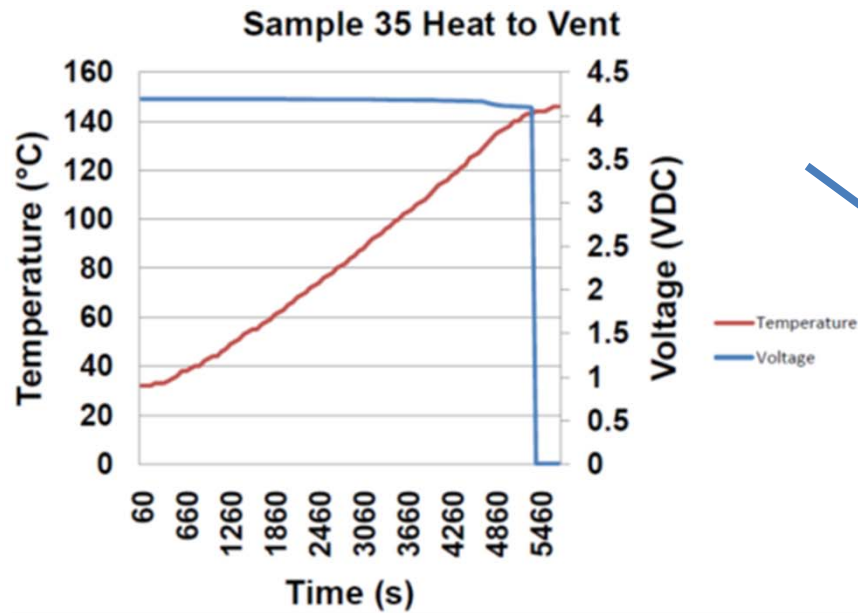
Overdischarge (Discharge to 1 VDC & Charge-Discharge Cycle) Sample 16



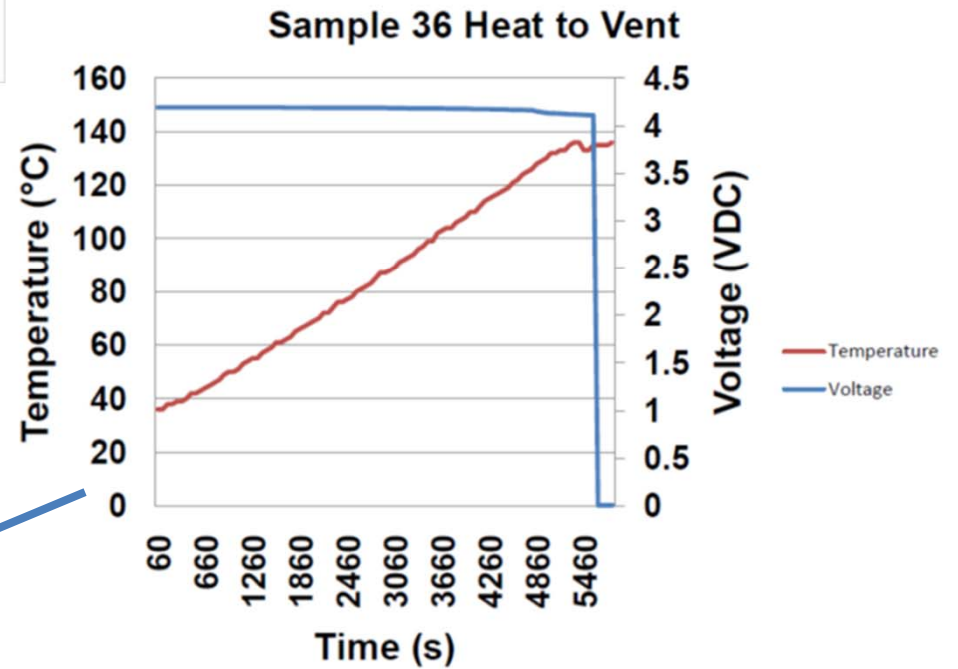
Overdischarge (Voltage Reversal) Sample 16



# Moli STOBA 2.0 Ah Li-ion Cell



**Temp Ramp Rate: 1.5 deg C/min.**



# Moli STOBA 2.0 Ah Li-ion Cell

## Vent and Burst Pressure Test Data

Sample 14 vent opened at a pressure of 155 psi.

Sample 15 vent opened at a pressure of 145 psi.

Sample 10 burst at a pressure of 859 psi. Failure around crimp seal.

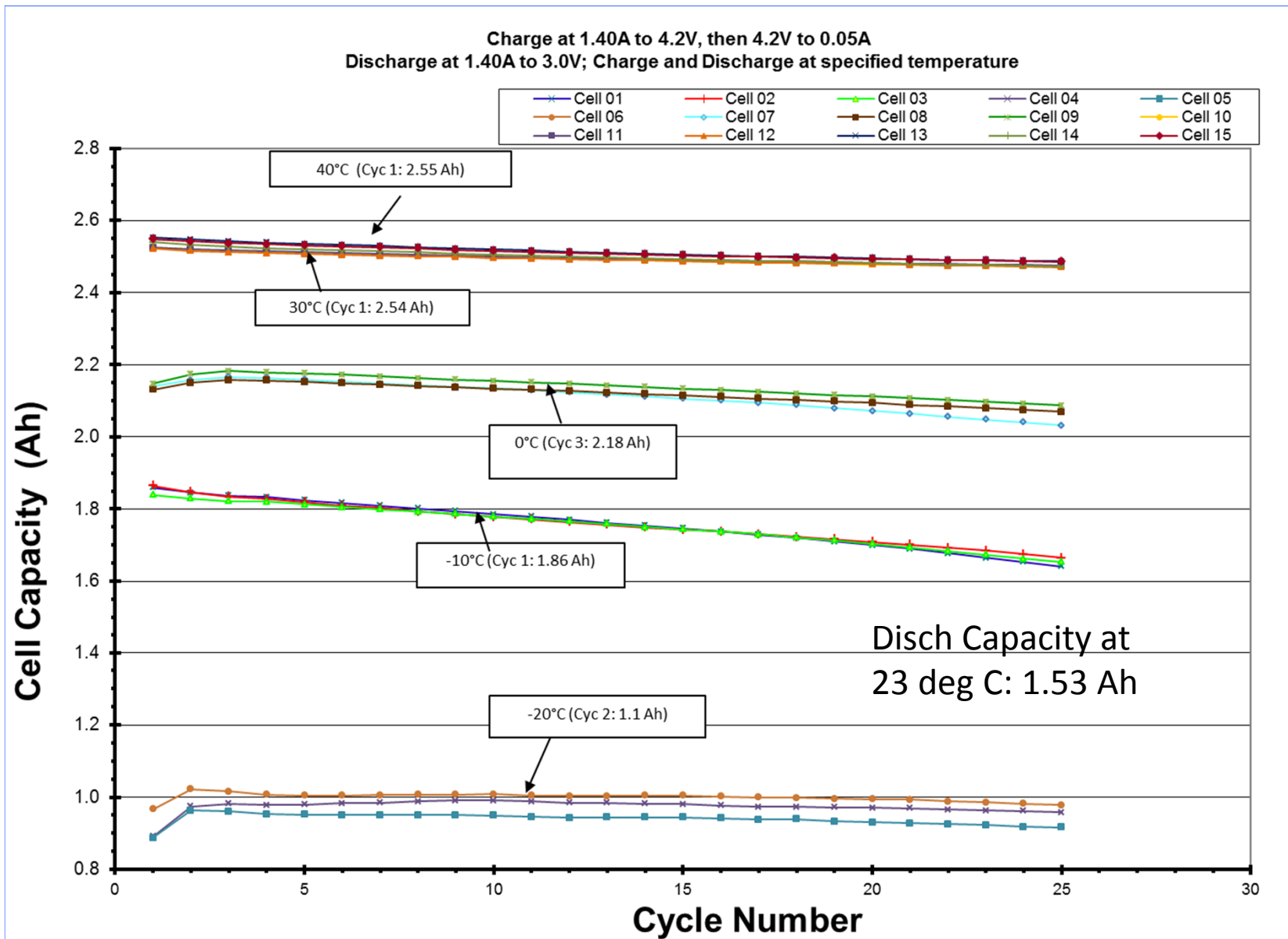
Sample 11 burst at a pressure of 645 psi. Failure around crimp seal.



# LG 2.8 Ah Li-ion 18650 Cell

## Performance at Various Temperatures

# LG 2.8 Ah Li-ion 18650 Cell



# Acknowledgments

- PCTest Engineering
- Symmetry Resources Inc.
- Element Inc.